

**PROCESSED STRONG-MOTION RECORDS FROM THE
CSMIP/NSF TREASURE ISLAND GEOTECHNICAL ARRAY
FOR THE GILROY EARTHQUAKE OF 16 JANUARY 1993**

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INTRODUCTION

Important data for geotechnical engineering was recorded at the joint CSMIP/National Science Foundation (NSF) Treasure Island Geotechnical Array near San Francisco. Low-amplitude accelerograms were recorded at the array from a distant M_L 5.3 earthquake. The earthquake occurred near Gilroy, approximately 120 km away. In this soft-soil site-response array accelerometers are installed at the surface and in 5 nearby boreholes. The borehole accelerometers are located below the sandstone and shale bedrock surface (104 m) and at 4 intermediate locations in the soil profile (7, 16, 31, 44 m).

The peak acceleration, velocity and displacement at the array are 0.0142 g, 0.86 cm/sec and 0.08 cm, respectively. These peaks were recorded on channel 1, located on the surface in the north-south direction. In the north-south direction, peak acceleration ranged from 0.0032 g in bedrock to 0.0142 g at the surface. In the east-west direction, peak accelerations of 0.0024 and 0.0133 g were recorded in bedrock and at the surface, respectively. In contrast, on the vertical component the peak acceleration ranged from 0.0021 g in bedrock to 0.0044 g at the surface. The processing of these records occurred in parallel with digitization and processing of many large amplitude records from the Landers earthquake.

THE CSMIP/NSF TREASURE ISLAND GEOTECHNICAL ARRAY

The Treasure Island Geotechnical Array is a recently installed joint project of CSMIP and the NSF (de Alba and others, 1993). This installation fits into the framework of the proposed network of U.S. Geotechnical Test Sites (Benoit and de Alba, 1988). One of the goals of the array is to explain the observed amplification of rock motion by soil deposits observed during the magnitude 7 Loma Prieta earthquake (de Alba and others, 1993). Figure 1 shows a plan view of the array and instrumentation.

Site Geology Treasure Island is a 400-acre manmade island created in the 1930's by hydraulic filling. The island was constructed over a natural sand spit and Bay Mud and is located in San Francisco Bay north of the Franciscan outcrops on Yerba Buena Island. Figure 2 shows the depth profile of the instrumentation. The shear-wave velocity and lithology (after Gibbs and others, 1992) are also shown. At the array site there is approximately 12 m of hydraulic fill and sand overlying about 15 m of medium-stiff Holocene Bay Mud (soft silt and clay sediments) over dense sand and stiff Pleistocene Bay Mud (Old Bay Clay). Generally, the clay stiffness increases with depth. Franciscan sandstone and shale is encountered at 91 m beneath the site. The hydraulic fill consists of silty fine sands with clayey zones. The fill is in a relatively loose condition due to the construction method. After the Loma Prieta earthquake sand boils on Treasure Island provided evidence of liquefaction within 100 m of the array site (Shakal and others, 1989; EERI, 1990). Array site characterization studies are described in greater detail in Gibbs and others (1992), de Alba and others (1993), and EPRI (1993).

Instrumentation The array includes six triaxial accelerometers that have been installed at the surface and in five boreholes. As indicated in Figure 2, borehole acceleration data is recorded in the artificial fill at 7 m; near the top of the Young Bay Mud at 16 m; near the top of a dense gray sand at 33 m; near the top of the Old Bay Mud at 44 m; and below the bedrock surface at 104 m. The 5 borehole accelerometers were installed in 5" PVC pipe that was grouted in place. The accelerometers are secured in the borehole using the CSMIP orientation and locking system (Shakal and Petersen, 1992). At the time of the earthquake the array installation was not yet complete because the pore pressure sensors had not been installed.

Observations The peak acceleration (A_{pk}) ranged from 0.0142 g at the surface to 0.0032 g at 104 m depth in bedrock in the north-south direction. In the east-west direction, A_{pk} ranged from 0.0133 g at the surface to 0.0024 g in bedrock. An amplification ratio of peak acceleration from bedrock to the surface of greater than a 4 is observed on both of the low-amplitude horizontal components.

Horizontal Acceleration Surface A_{pk} = 0.0142 g = 4.4
Amplification Ratio: Bedrock A_{pk} 0.0032 g

In contrast, on the vertical component the peak acceleration ranged from 0.0044 g at the surface to 0.0021 g in bedrock with an amplification ratio of about 2 from bedrock to the surface.

Vertical Acceleration Surface A_{pk} = 0.0044 g = 2.1
Amplification Ratio: Bedrock A_{pk} 0.0021 g

In addition, the acceleration waveforms recorded at the surface and subsurface soil instruments have significantly longer duration than the bedrock record. On all three components, the duration (Dobry and others, 1978) is between 8 and 10 seconds in the bedrock, between 15 to 25 seconds in the soil profile and between 15 and 20 seconds at the surface. The longest durations were recorded in the soil profile at 16 m (51 ft).

Instrumented-corrected and band-pass filtered peak velocity (V_{pk}) and displacement (D_{pk}) are less than 1 cm/sec and 0.1 cm, respectively for all records. The amplification ratios of peak velocity and displacement from the bedrock to the surface are greater than 3 for the horizontal components. For example, in the north-south direction peak velocity ranges from 0.154 in bedrock to 0.857 cm/sec at the surface.

Horizontal Velocity Surface V_{pk} = 0.857 cm/sec = 5.6
Amplification Ratio: Bedrock V_{pk} 0.154 cm/sec

Horizontal Displacement Surface D_{pk} = 0.078 cm = 6.5
Amplification Ratio: Bedrock D_{pk} 0.012

In contrast, the amplification ratio of peak vertical velocity and displacement from the bedrock to the surface are both near 1.

Vertical Velocity Surface Vpk = 0.220 cm/sec = 1.2
Amplification Ratio: Bedrock Vpk 0.178 cm/sec

Vertical Displacement Surface Dpk = 0.022 cm = 1.3
Amplification Ratio: Bedrock Dpk 0.017 cm

Similar to acceleration, the durations of the displacement and velocity waveforms recorded at the surface and in the soil profile are longer than recorded in the bedrock.

The response spectra computed from the surface and the soil profile recordings are generally larger than the bedrock spectrum. The spectra generally decrease in amplitude with increasing depth. The spectral amplification in the north-south direction is greater than 10 near 1 Hz. The east-west spectra show similar trends. However, the spectral amplification on the vertical component is generally 2 or less for the periods within the Usable Data Bandwidth.

PLOTS OF PROCESSED DATA

The processed data for the array recordings from the Gilroy Area earthquake are presented below. The order of the plots is as follows:

1. Phase 2 (Vol. 2) data: instrument and baseline-corrected acceleration, velocity and displacement. The data for the full processed length (39 seconds) are plotted with equal scaling for all channels. The 18 channels at the array are arranged by orientation (north-south (360°), up-down (Up), east-west (90°)) and plotted on a single page. The filter frequencies used in the processing are indicated on the plots. For these records, the Usable Data Bandwidth is from 0.51 to 23.6 Hz, (or 0.04 to 2.0 seconds period) (see Figure 3). The Usable Data Bandwidth was selected because of some noise aspects in the data recorded from the newly installed accelerometers.
2. Phase 2 (Vol. 2) data: instrument and baseline-corrected acceleration, velocity and displacement. The data for the full processed length are plotted with equal scaling for all channels; one channel per page.
3. Phase 3 (Vol. 3) data: response spectra. The pseudo-velocity spectra (PSV), the pseudo-acceleration spectra (PSA), the displacement spectra (SD), and the Fourier amplitude spectra (FS) are presented on a tripartite logarithmic plot for each channel. The spectra at the surface (channels 1 to 3) are plotted using the traditional ordinate, scaled to 400 in/sec; one channel per page. To display the low-amplitude spectra more completely, the response spectra are plotted using an ordinate scaled to 40 in/sec; three channels are plotted per page. The spectra are plotted for periods within the Usable Data Bandwidth.

ACKNOWLEDGEMENTS

The California Strong Motion Instrumentation Program extends its appreciation to the individuals and organizations which have permitted and cooperated in the installation of the CSMIP/NSF Treasure Island Geotechnical Array. The instrumentation at the array was partially carried out under grants from the NSF with principal investigators P. de Alba and J. Benoit of the University of New Hampshire and T. L. Youd of Brigham Young University. Other key contributors to the array and its documentation include R. Faris and T. Cuckler of the U.S. Navy; J. Schneider and the Electric Power Research Institute; T. Fumal and J. Gibbs of the U.S. Geological Survey; and I. M. Idriss of U.C. Davis who have all been involved with the instrumentation or site characterization. In addition, CSMIP acknowledges the efforts of the members of the Treasure Island Geotechnical Test Site Advisory Committee and the members of the Strong Motion Instrumentation Advisory Committee and its subcommittees. The authors would also like to recognize the CSMIP technicians under the direction of C. Petersen and R. Payne for their diligence in installing the instruments and recovering the records. N. Sandhu assisted in processing and plotting the data.

REFERENCES

- de Alba, P., J. Benoit, T. L. Youd, A. F. Shakal, D. G. Pass and J. L. Carter (1993). Deep instrumentation array at Treasure Island Naval Station, U.S. Geological Survey Professional Paper (in press).
- Benoit, J. and P. de Alba (editors) (1988). Designated sites for geotechnical experimentation in the United States, in Proceedings of the Workshop at the University of New Hampshire.
- Dobry, R., I. M. Idriss and E. Ng (1978). Duration characteristics of horizontal components of strong-motion earthquake records, Bulletin Seismological Society of America, 68, 1487-1520.
- EERI (1990). Loma Prieta earthquake reconnaissance report, Earthquake Spectra, 6, (supplement), 448 pp.
- EPRI (1993). Guidelines for determining design ground motions, Electric Power Research Institute, vol 1-4, Report TR-102293.
- Gibbs, J. F., T. E. Fumal, D. M. Boore and W. B. Joyner (1992). Seismic velocities and geologic logs from borehole measurements at seven strong-motion stations that recorded the Loma Prieta earthquake, U.S. Geological Survey Open-File Report 92-287.
- Shakal, A., M. Huang, M. Reichle, C. Ventura, T. Cao, R. Sherburne, M. Savage, R. Darragh, and C. Petersen (1989). CSMIP strong-motion records from the Santa Cruz Mountains (Loma Prieta), California earthquake of 17 October 1989, California, Division of Mines and Geology, Office of Strong Motion Studies Report, OSMS 89-06, 196 pp.
- Shakal, A. F. and C. P. Petersen (1992). Downhole strong-motion accelerometry: Objectives and techniques, Seismological Research Letters, 63, 30.

TREASURE ISLAND GEOTECHNICAL ARRAY

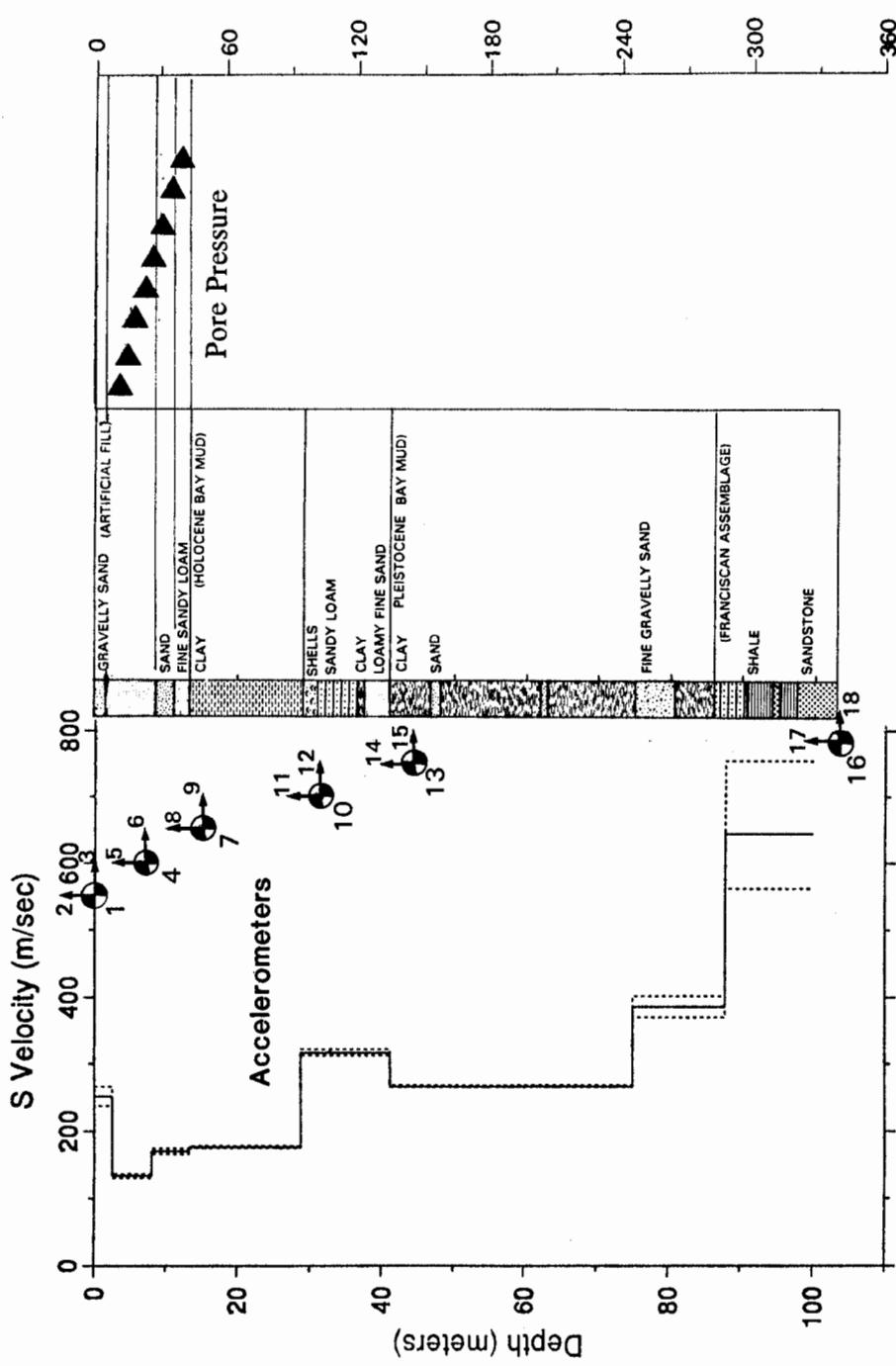


Figure 1. Plan view of the CSMP/NSF Treasure Island Geotechnical Array instrumentation. Accelerometers at the surface and at depths of 7 m (24'), 16 m (51'), 31 m (102'), 44 m (145') and 104 m (340') are denoted by hatched circles. At each location the three components are oriented north, up and east. The channel numbers, channel orientation and recording depth (in feet) are also shown for each accelerometer. The array also includes 8 pore pressure sensors (piezometers) denoted by solid triangles. These sensors are installed at depths of 3 through 11.7 m (10 through 38 ft). These sensors monitor the dynamically-induced pore pressure in the sand but were not yet installed at the time of this earthquake. The installation of these sensors is described in more detail in de Alba and others (1993).

TREASURE ISLAND GEOTECHNICAL ARRAY

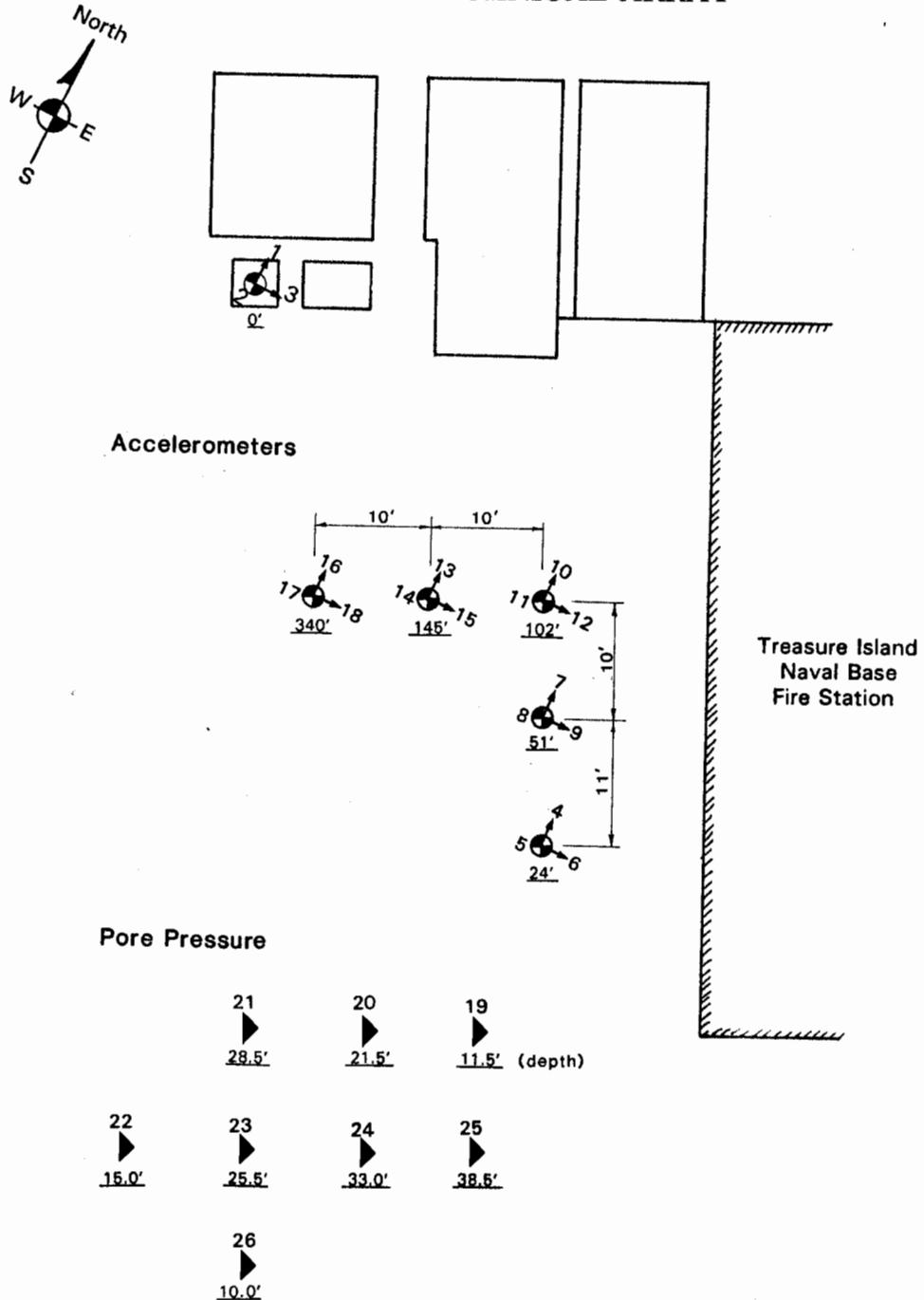
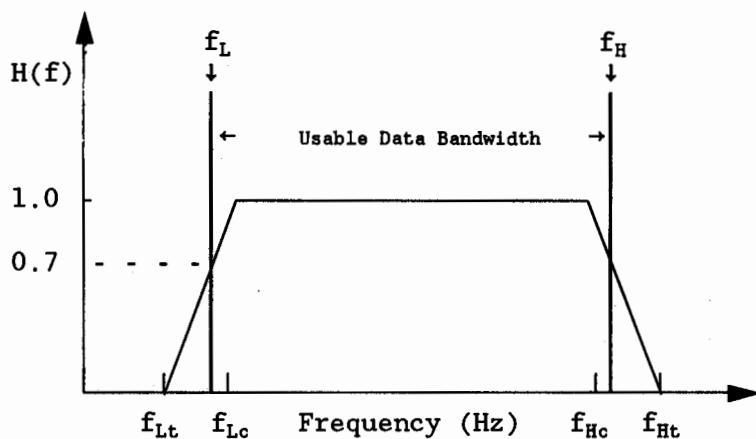


Figure 2. The CSMIP/NSF Treasure Island Geotechnical Array instrumentation. Accelerometers at the surface and at depths of 7 m (24'), 16 m (51'), 31 m (102'), 44 m (145') and 104 m (340') are denoted by hatched circles. The channel number and orientation are shown for each component. The U.S. Geological Survey shear-wave velocity and lithology log from Gibbs and others (1992) are shown (modified from Gibbs and others, 1992). The 8 pore pressure sensors (piezometers) are denoted by solid triangles. The channel number and depth (feet) are shown for each sensor.

DEFINITION OF USABLE DATA BANDWIDTH

The filter bands for each record are indicated on the plots for the Phase 2 and Phase 3 data. In standard processing, the digitized data are processed and filtered using Ormsby filters. The data are first low-pass filtered using a high-frequency filter with a corner frequency of 23 Hz and a roll-off termination frequency of 25 Hz. Then the data are high-pass filtered using a low-frequency filter with a corner frequency of 0.07 Hz and a roll-off termination of 0.05 Hz. Therefore, the Phase 2 data is the result of the digitized data being filtered by the bandpass filter $H(f)$ with ramps as shown in the figure:

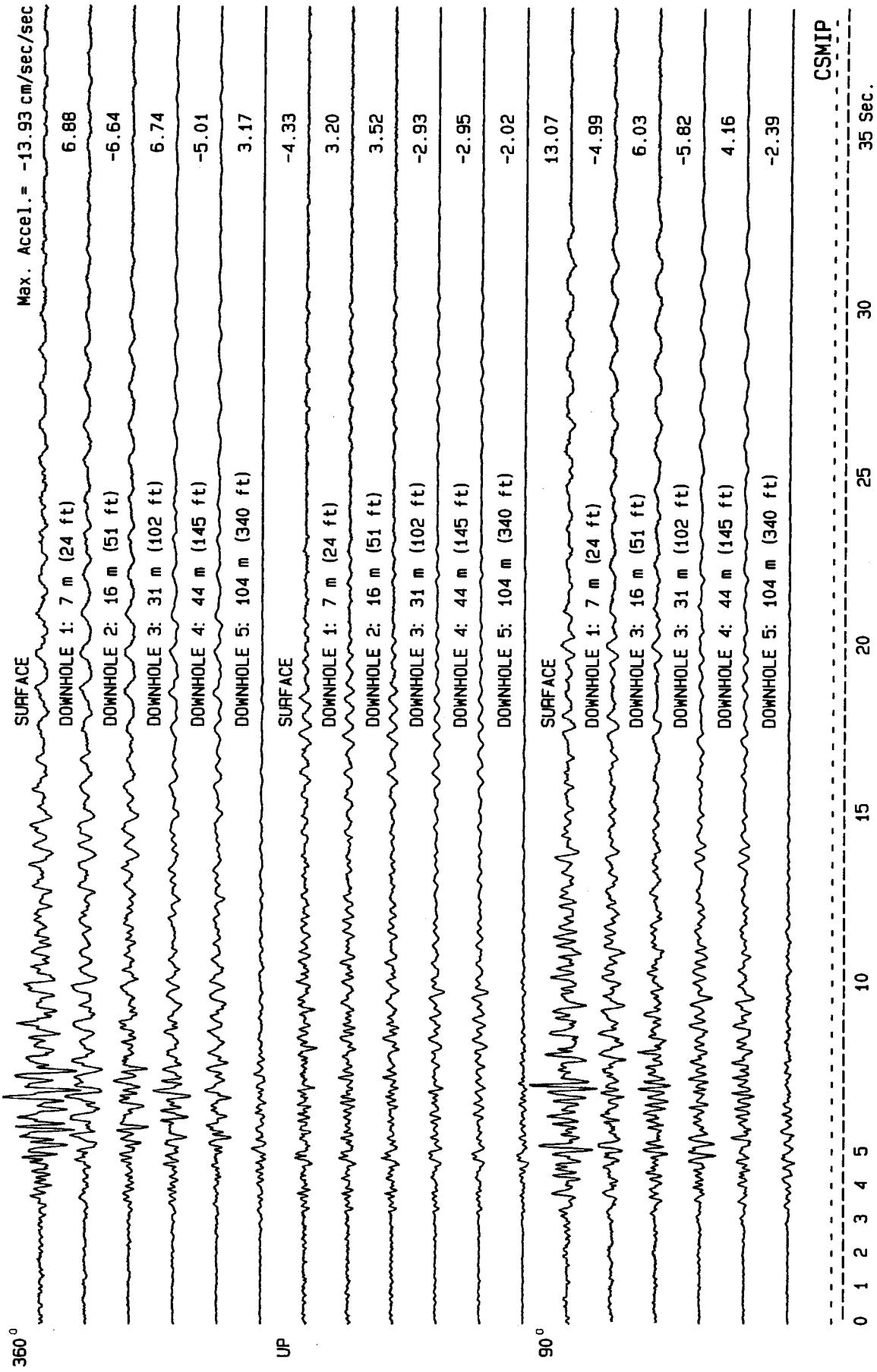


The Usable Data Bandwidth is defined as the band between frequencies f_H and f_L , where f_H and f_L are the -3 dB points on the high-frequency and low-frequency ramps, respectively. The value of $H(f)$ is approximately equal to 0.7 for -3 dB (see Notes). The user should only use these data for analyses within this bandwidth. For these records, the Usable Data Bandwidth is 0.51 Hz to 23.6 Hz (or 0.042 to 2.0 seconds period).

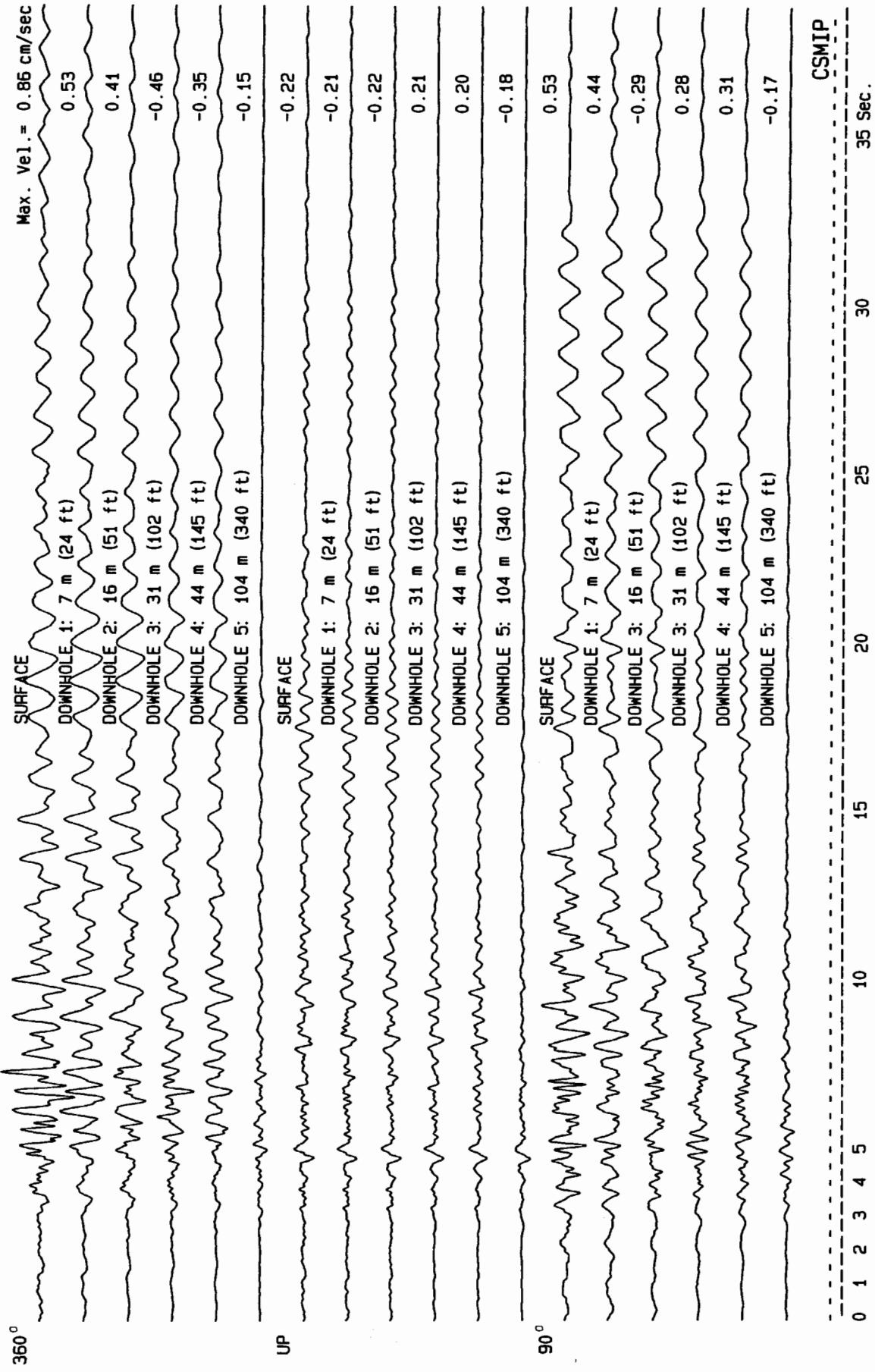
Notes:

- 1) The values of f_H and f_L can be calculated from the corner frequencies (f_{Hc} , f_{Lc}) and the roll-off termination frequencies (f_{Ht} , f_{Lt}) used in the processing by using the formulas $f_H = f_{Hc} + 0.3 * (f_{Ht} - f_{Hc})$ and $f_L = f_{Lc} - 0.3 * (f_{Lc} - f_{Lt})$. For example, the Usable Data Bandwidth for data bandpass-filtered with ramps at 0.30 to 0.60 Hz and 23.0 to 25.0 Hz is 0.51 Hz to 23.6 Hz (0.042 to 2.0 seconds period).
- 2) It is common in signal processing to plot $20 \log_{10}[H(f)]$ versus frequency, and express the ordinate value in decibels (abbreviated dB). Accordingly, 0 dB corresponds to a value of $H(f)$ equal to 1; 20 dB is equivalent to $H(f) = 10$, and -20 dB corresponds to $H(f) = 0.1$. Thus, at the -3 dB frequency point, the amplitude of the transfer function, $H(f)$, is reduced to 0.7, while the power transmitted by the filter, $H^2(f)$, is reduced to 0.5.

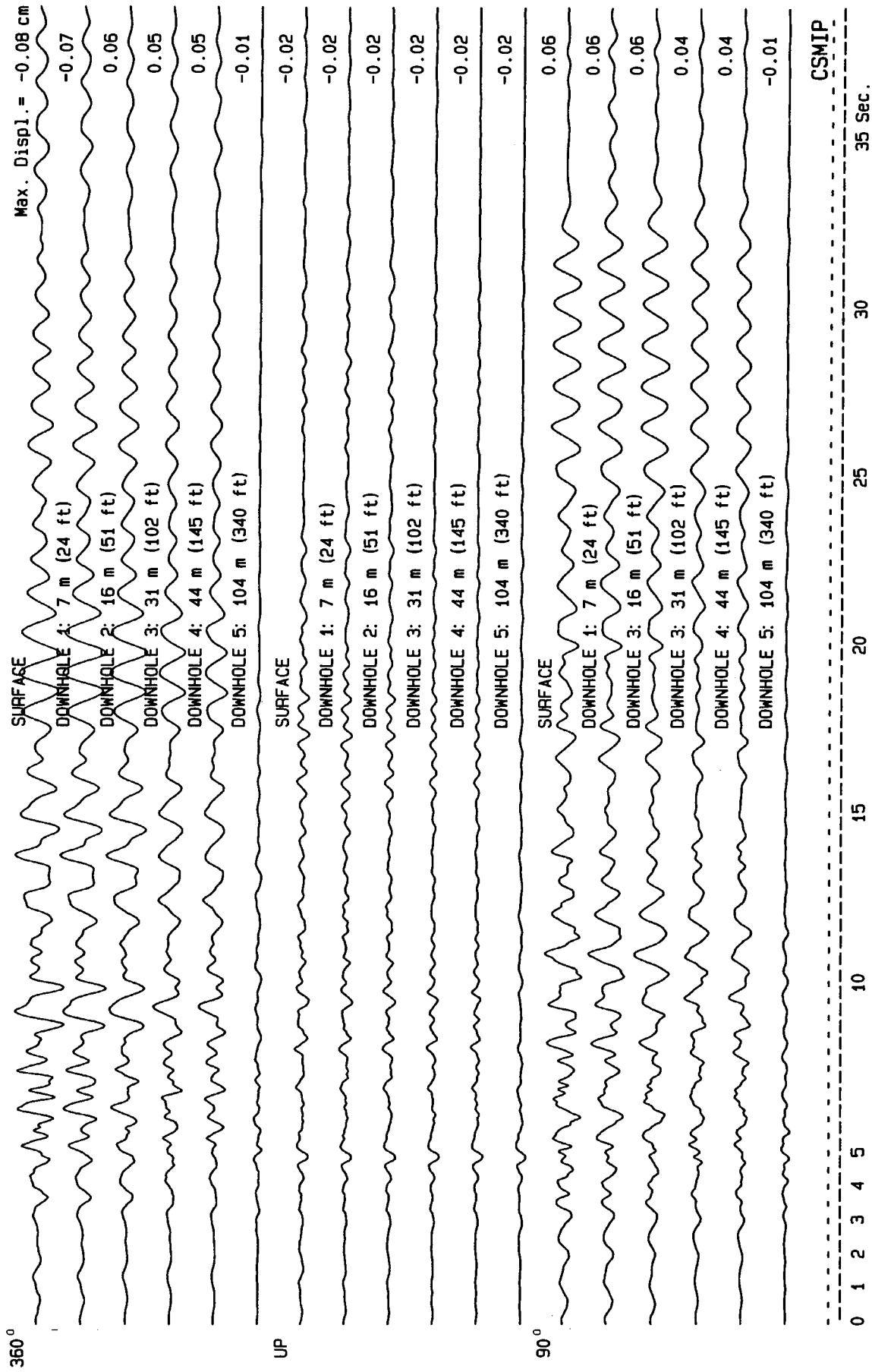
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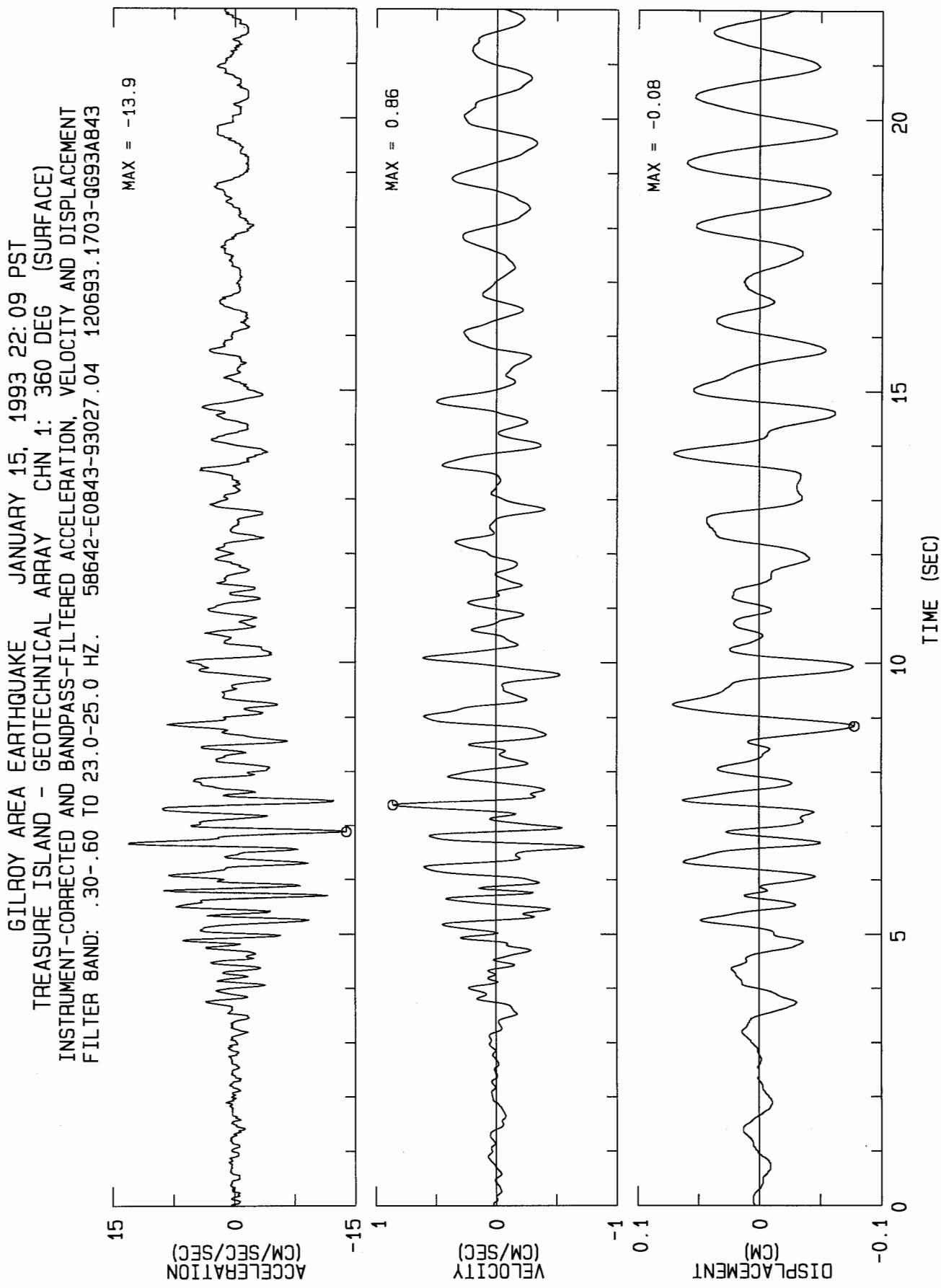


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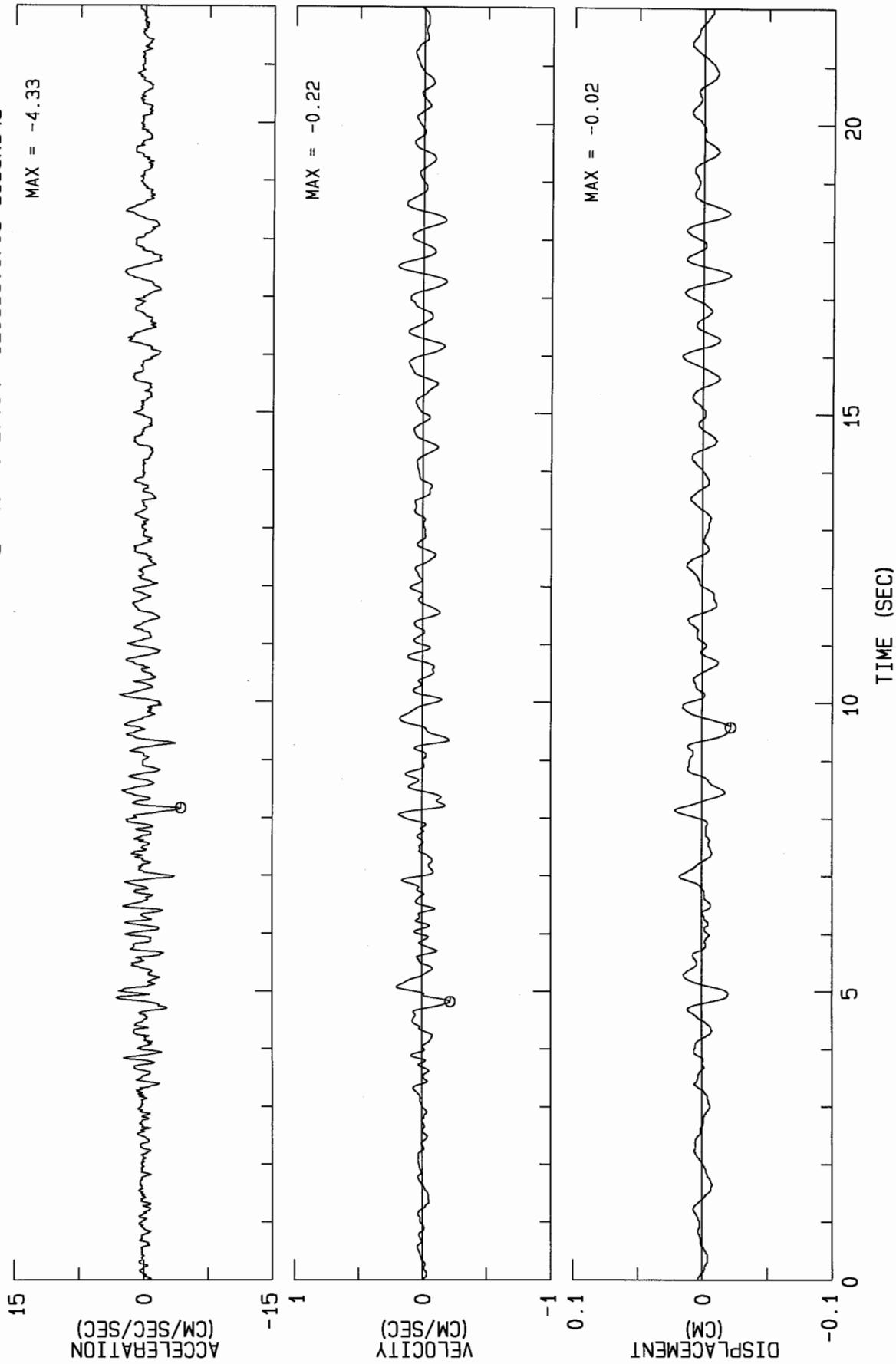


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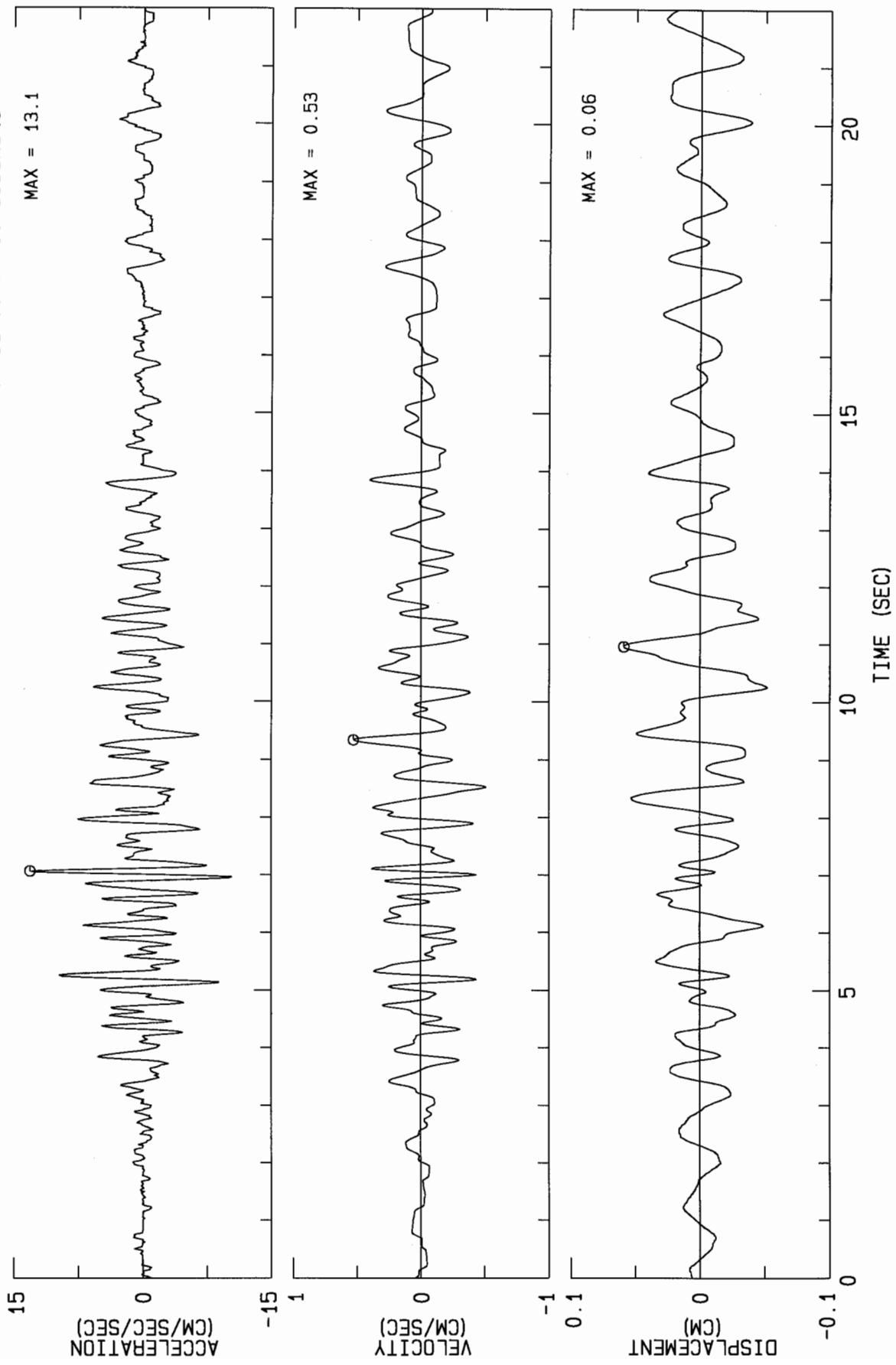


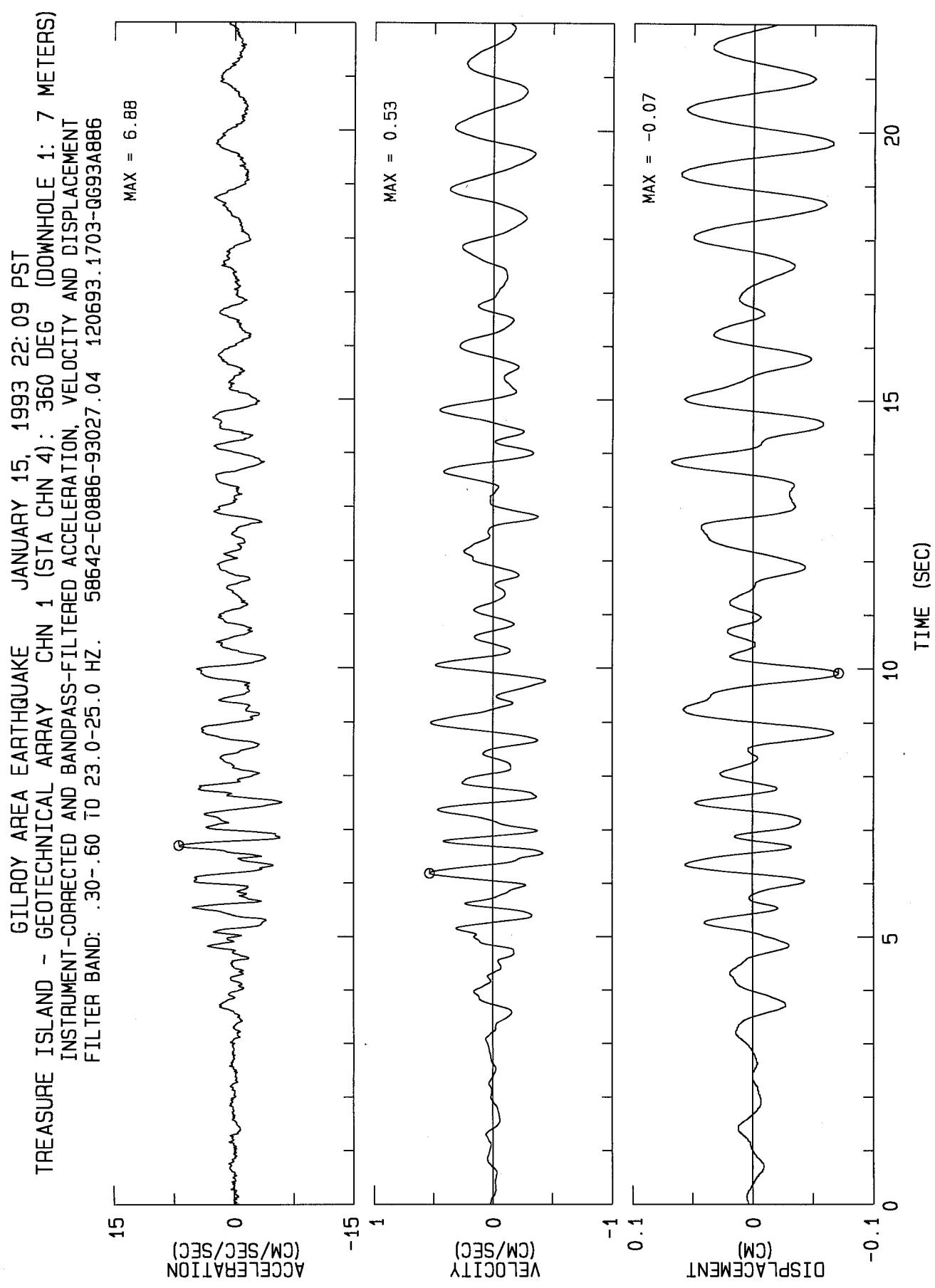


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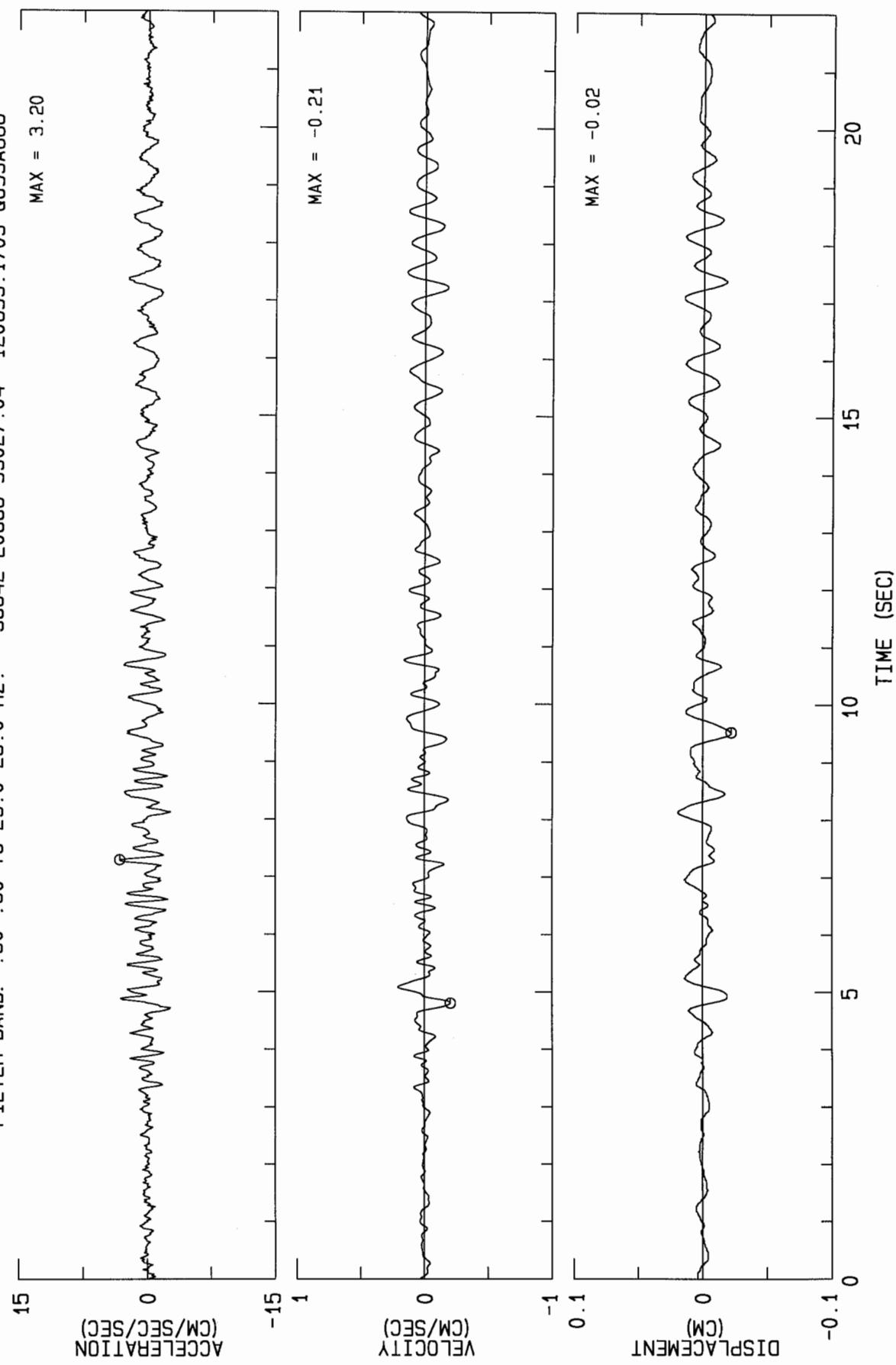


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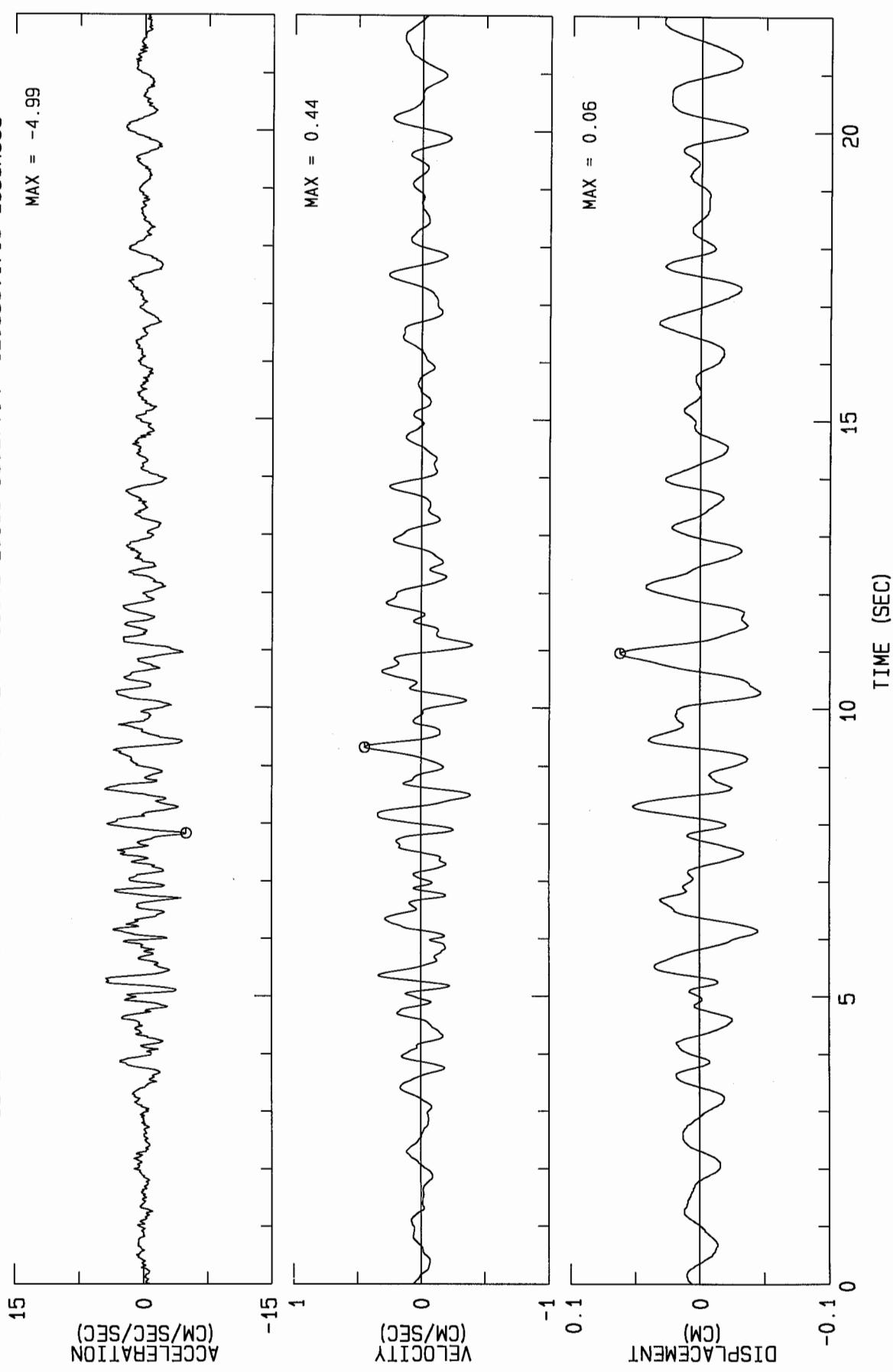




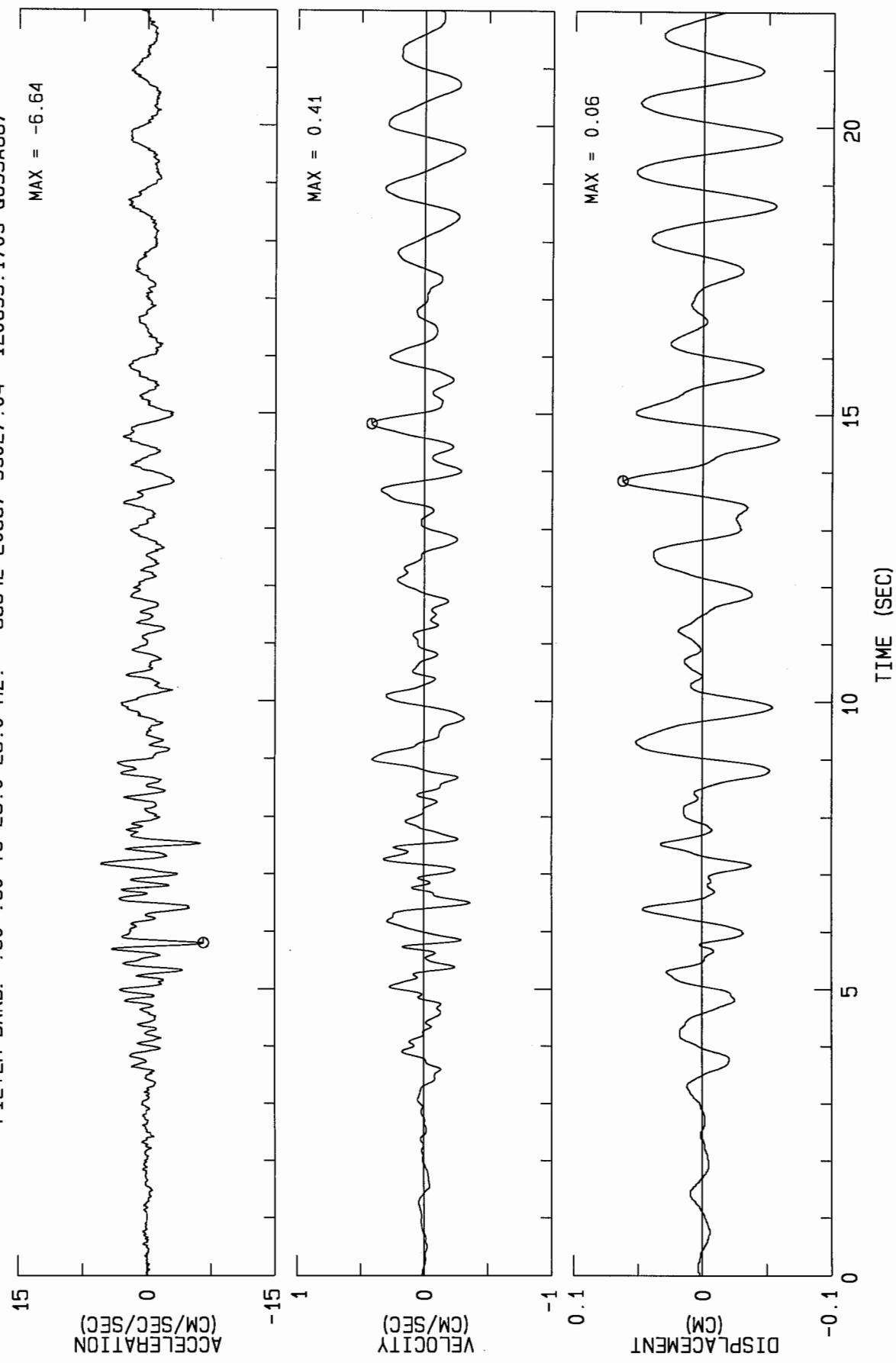
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INSTRUMENT-CORRECTED AND BANDPASS-FILTERED ACCELERATION, VELOCITY AND DISPLACEMENT
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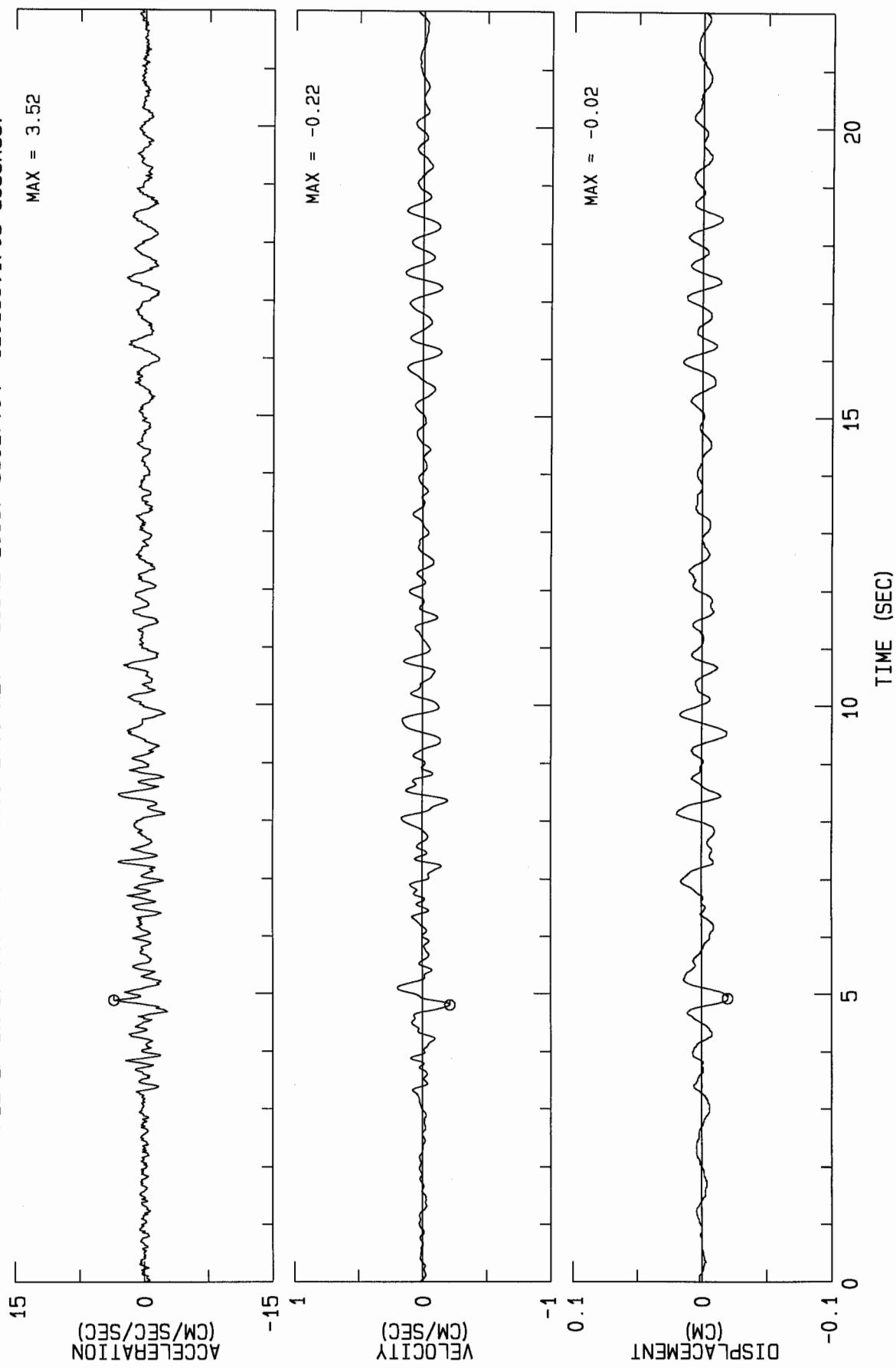
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 INSTRUMENT-CORRECTED AND BANDPASS-FILTERED ACCELERATION, VELOCITY AND DISPLACEMENT
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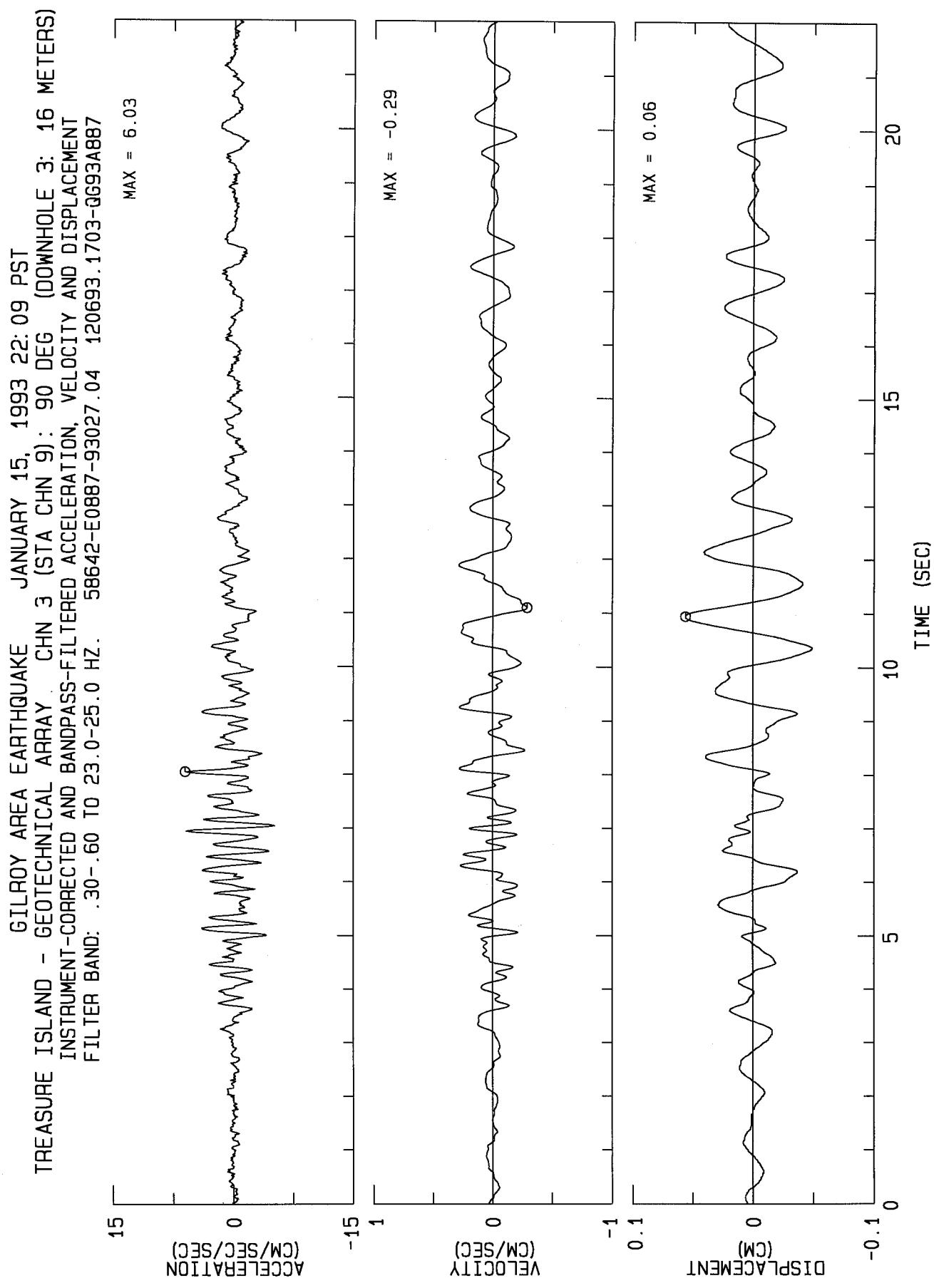


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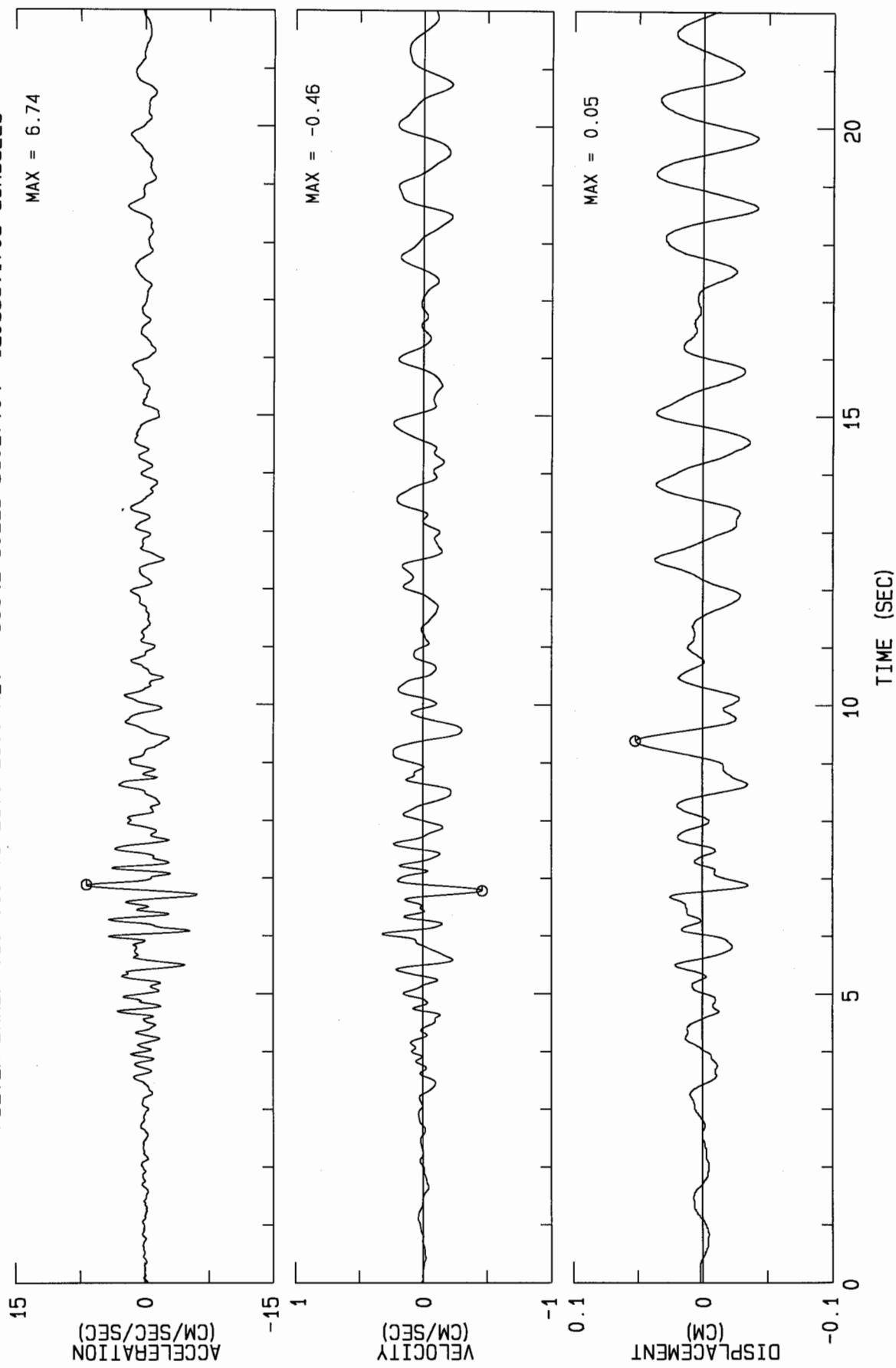


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INSTRUMENT-CORRECTED AND BANDPASS-FILTERED ACCELERATION, VELOCITY AND DISPLACEMENT
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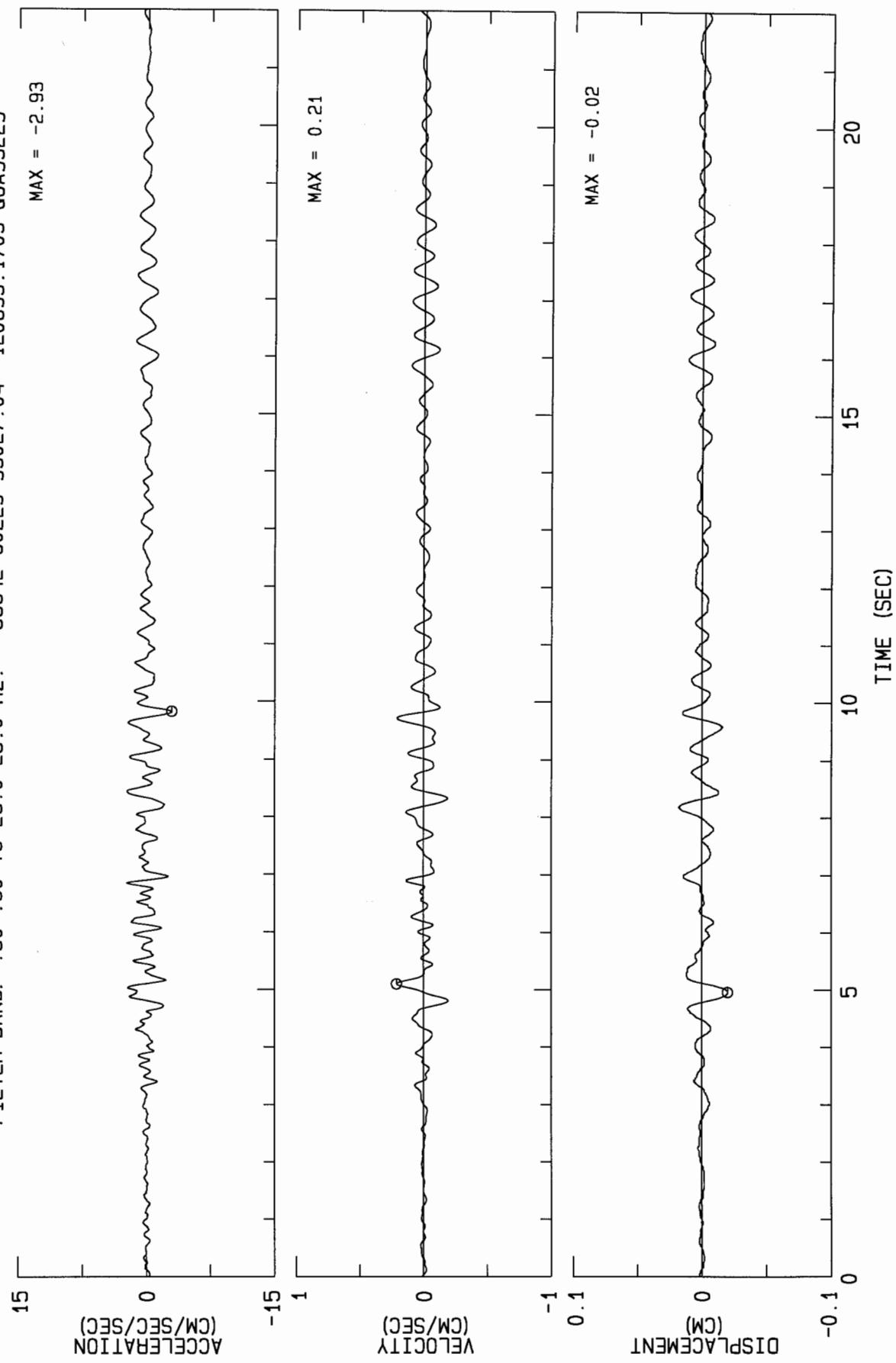




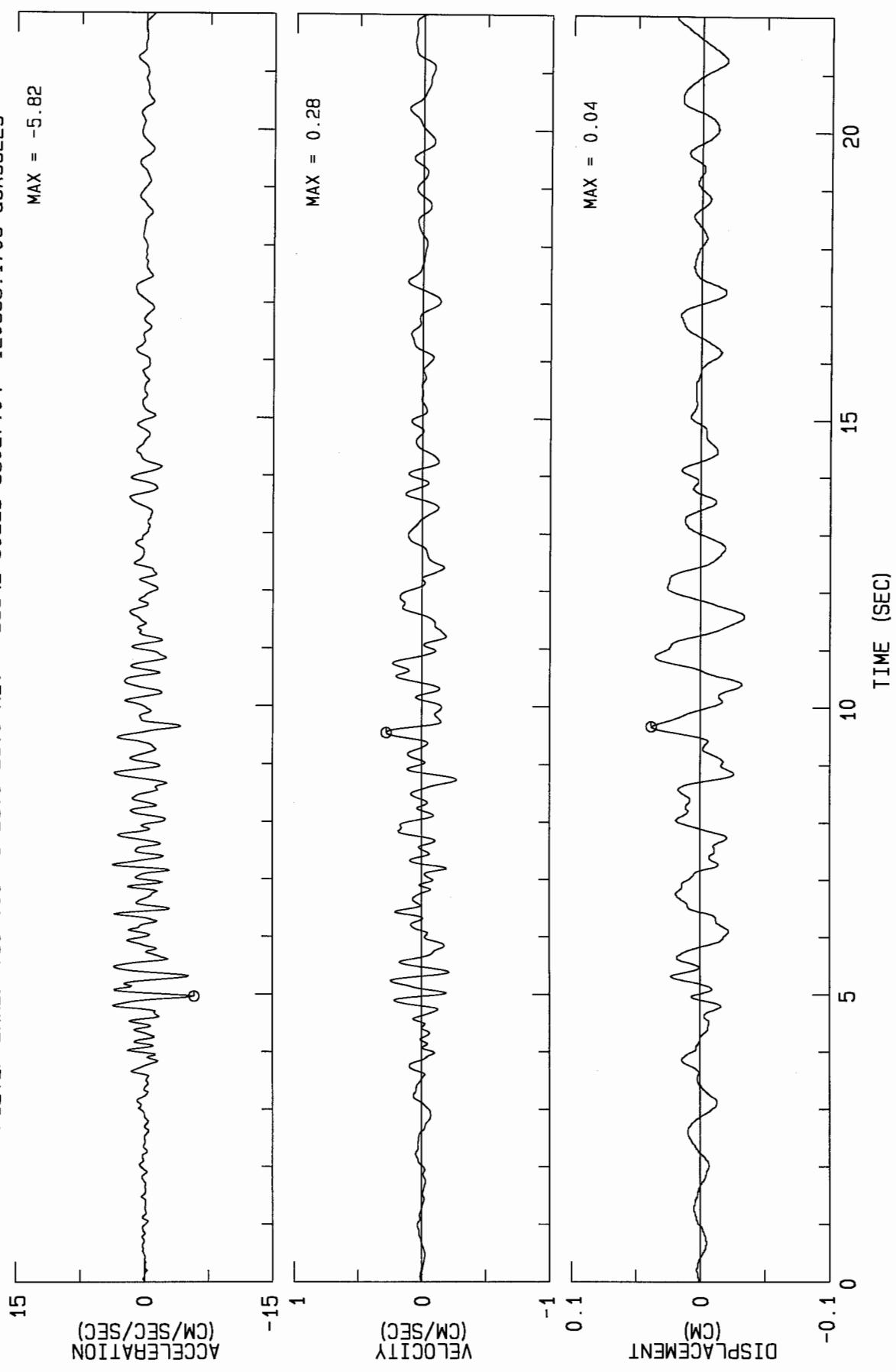
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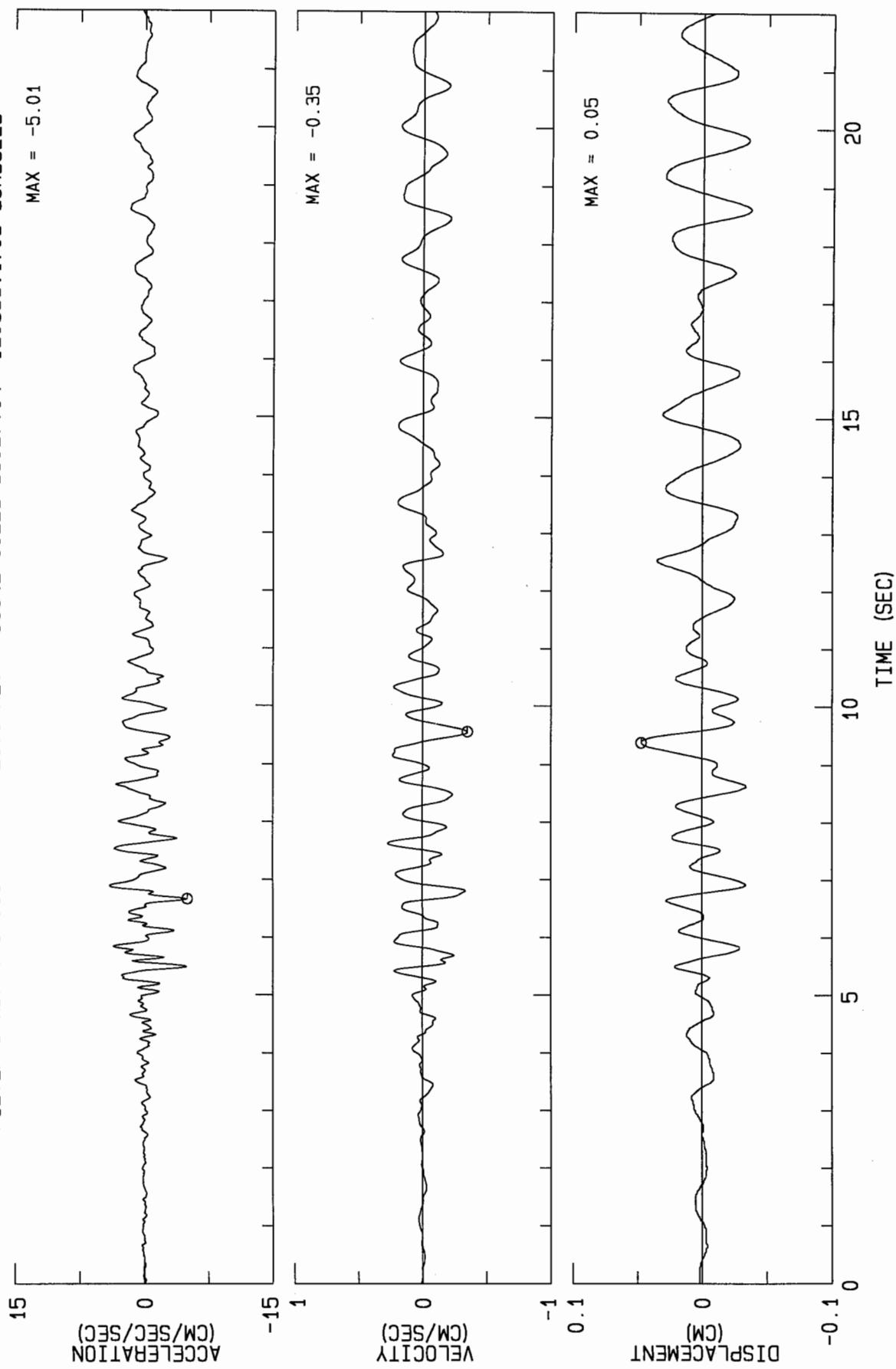
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INSTRUMENT-CORRECTED AND BANDPASS-FILTERED ACCELERATION, VELOCITY AND DISPLACEMENT
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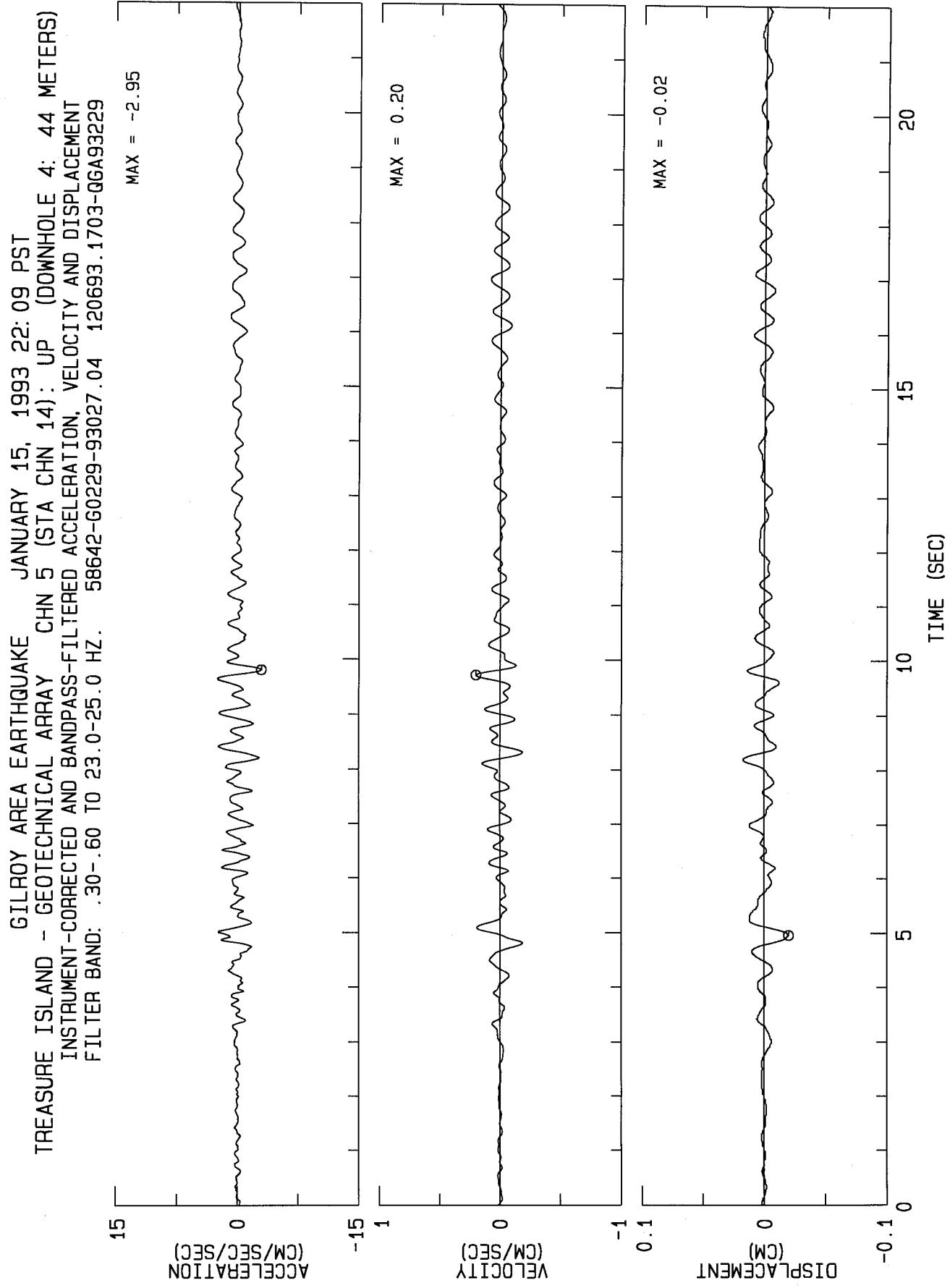


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TREASURE ISLAND - GEOTECHNICAL ARRAY CHN 3 (STA CHN 12): 90 DEG (DOWNHOLE 3: 31 METERS)
INSTRUMENT-CORRECTED AND BANDPASS-FILTERED ACCELERATION, VELOCITY AND DISPLACEMENT
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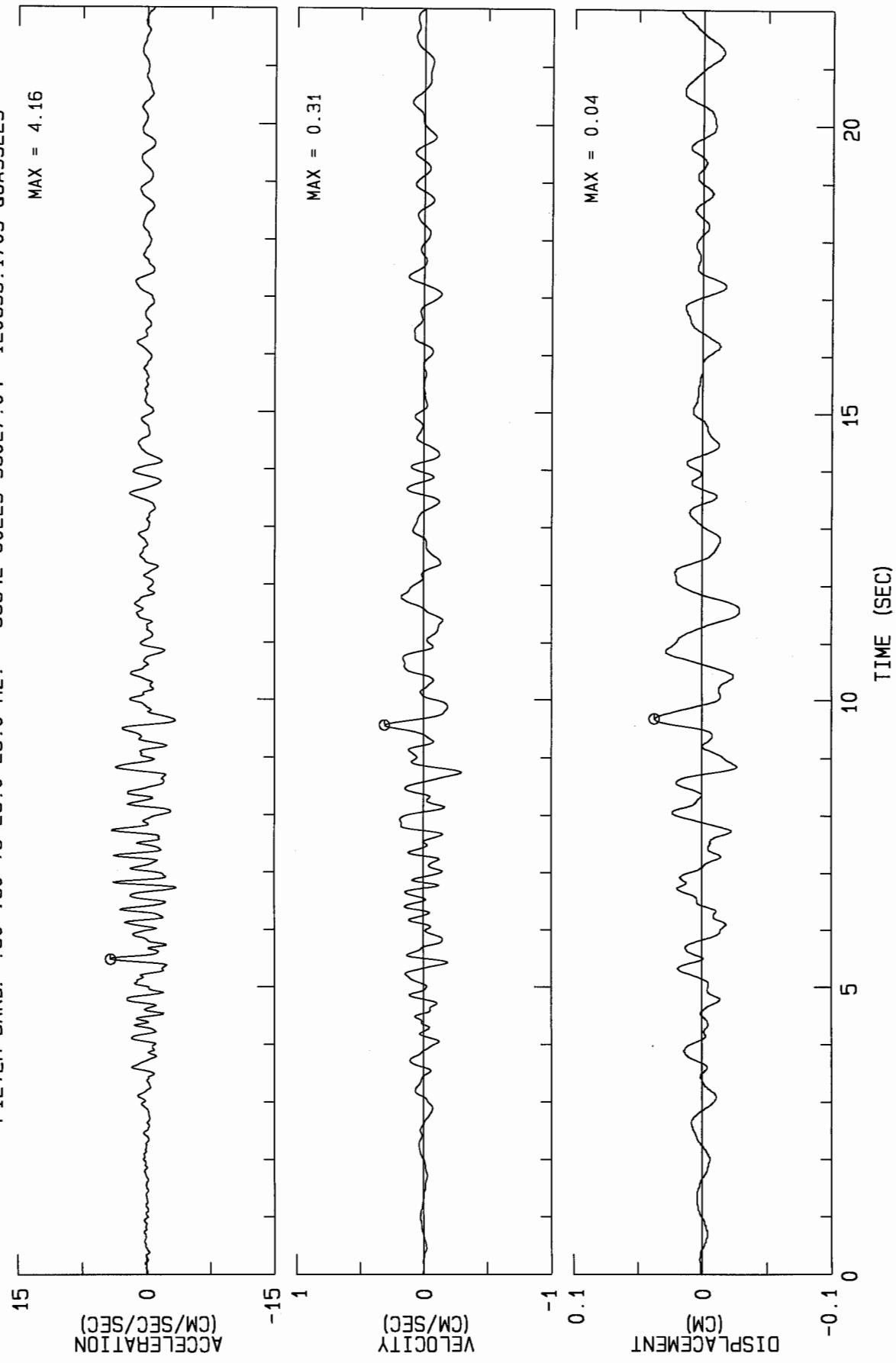


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INSTRUMENT-CORRECTED AND BANDPASS-FILTERED ACCELERATION, VELOCITY AND DISPLACEMENT
FILTER BAND: .30-.60 TO 23.0-25.0 HZ. 58642-60229-93027.04 120693.1703-QGA93229

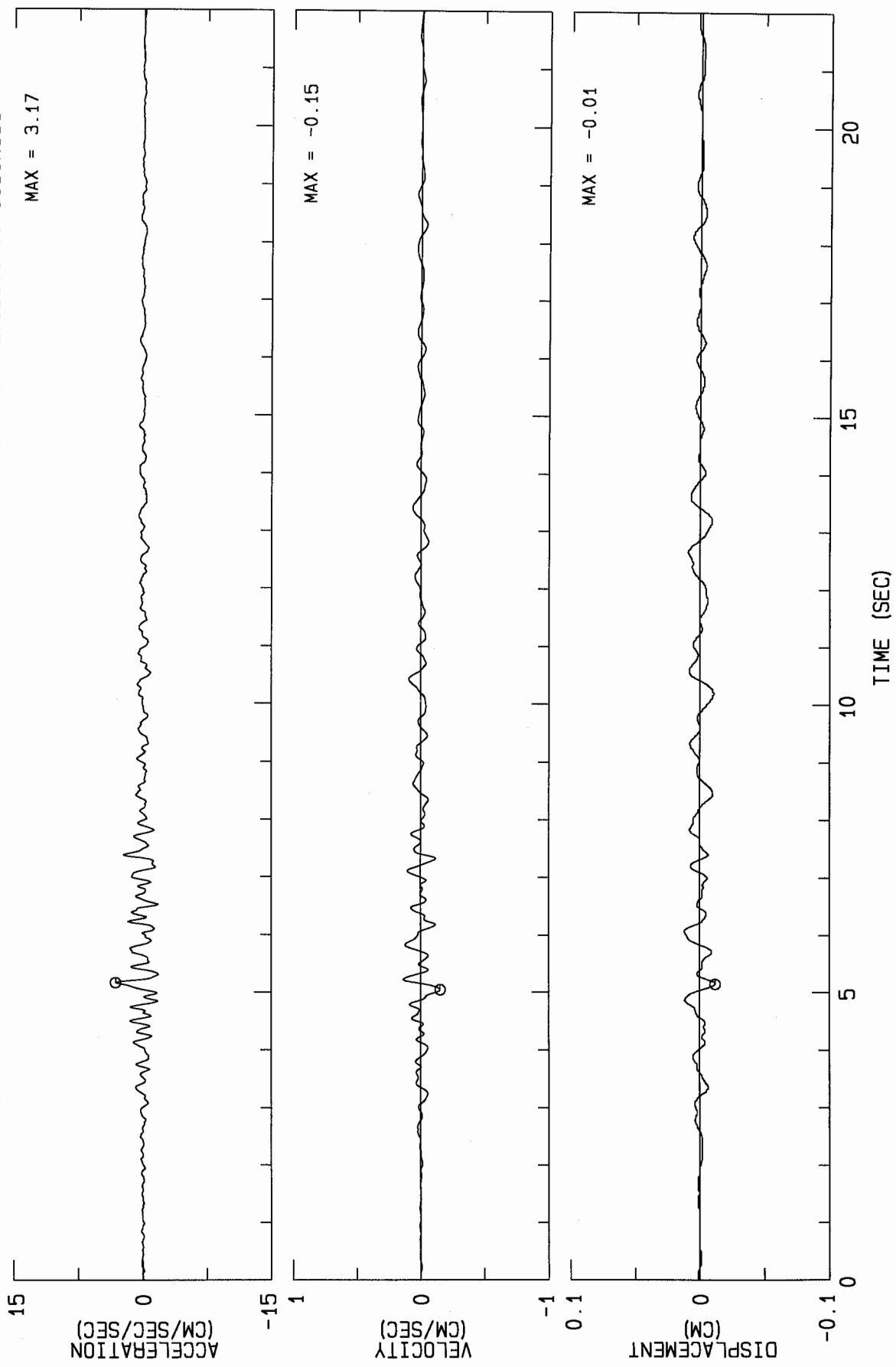


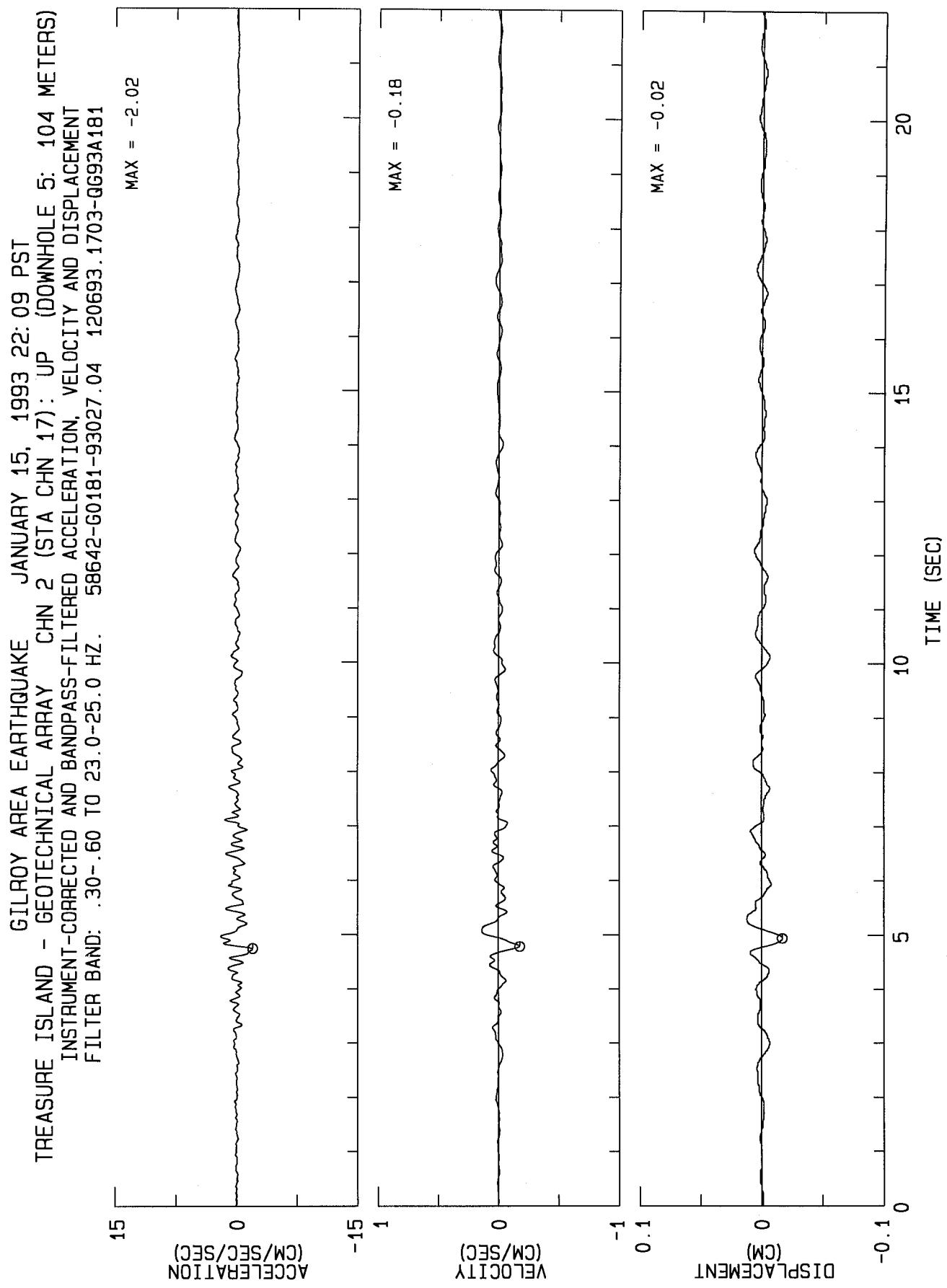


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 INSTRUMENT-CORRECTED AND BANDPASS-FILTERED ACCELERATION, VELOCITY AND DISPLACEMENT
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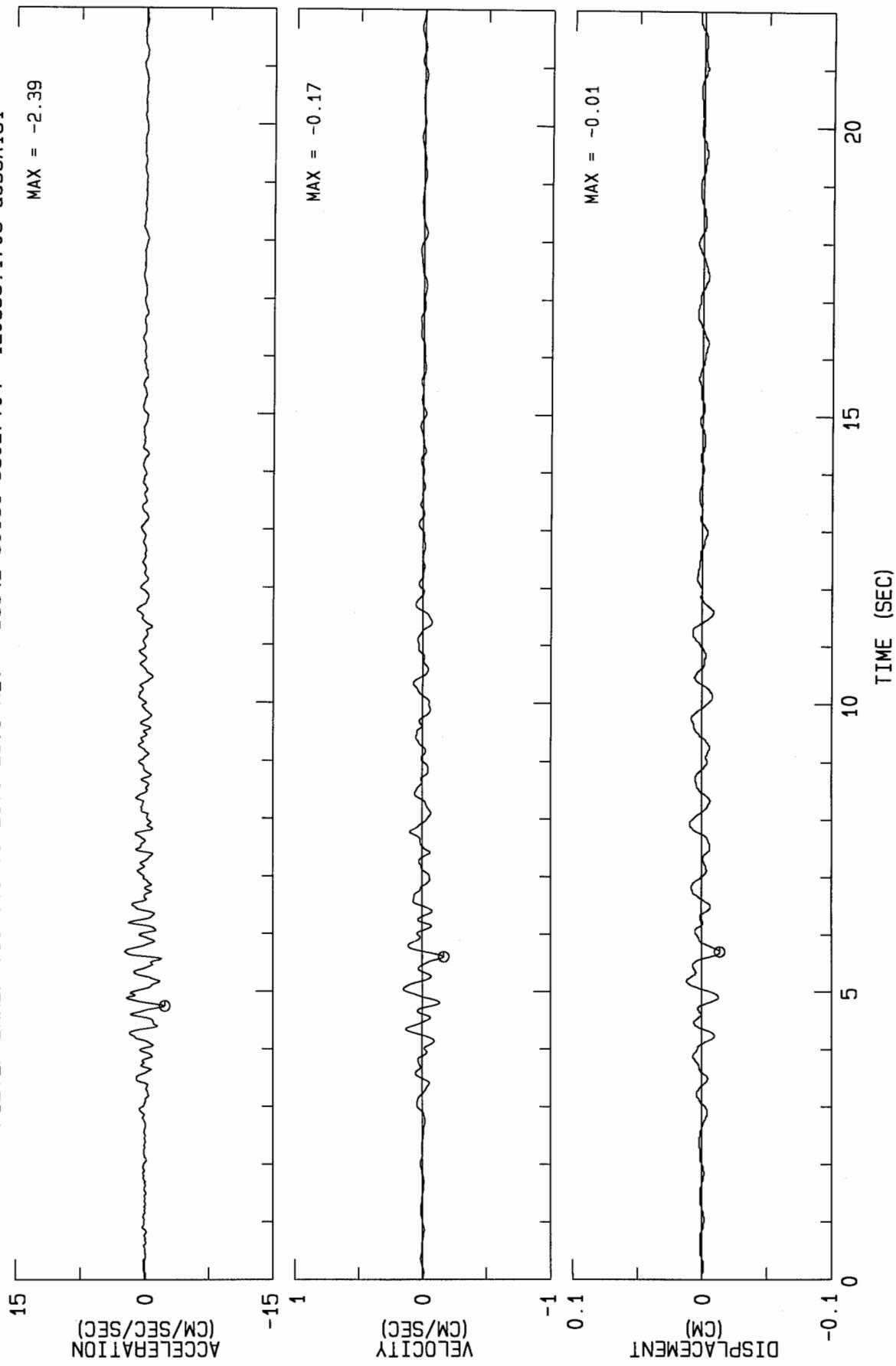


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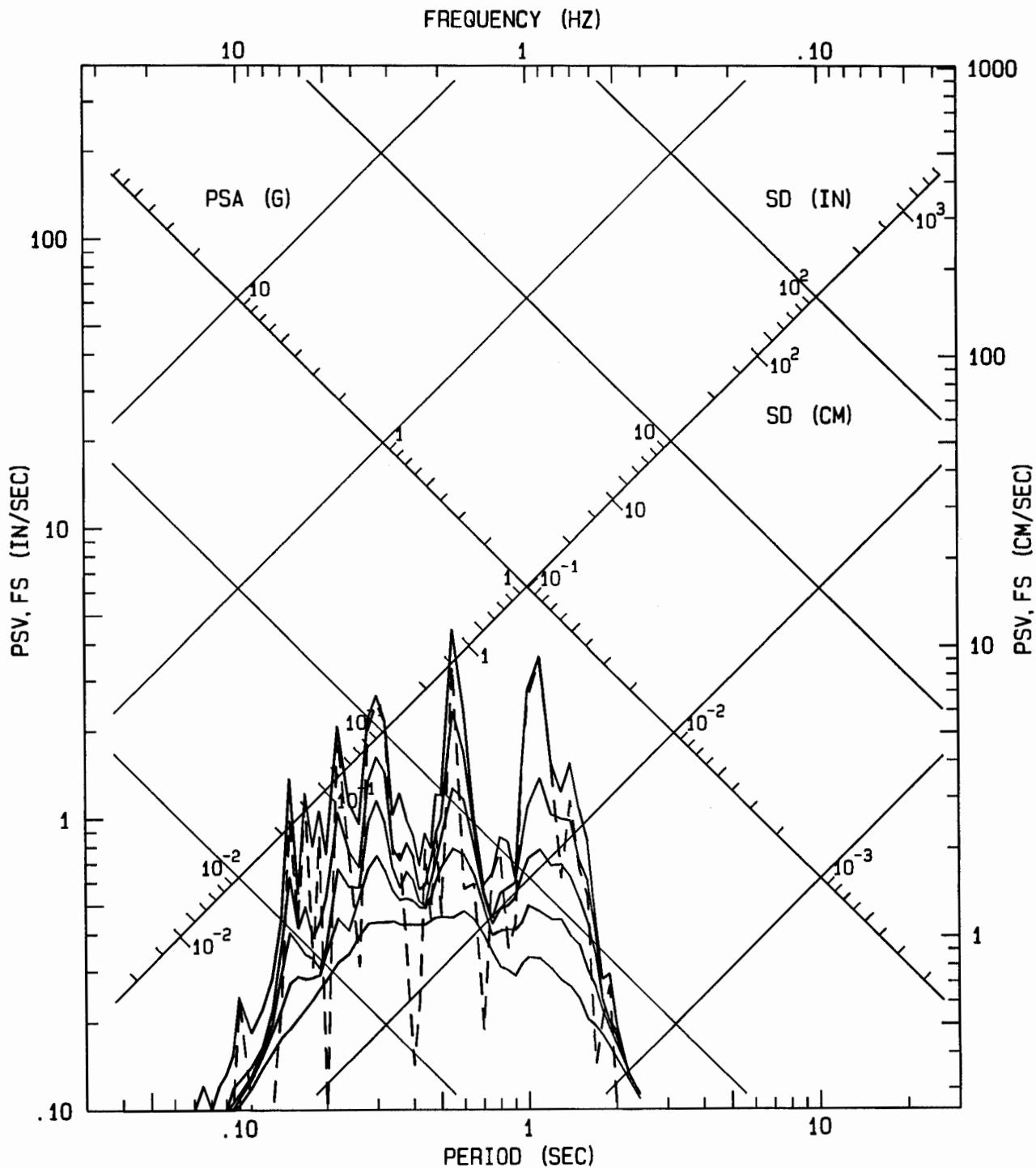


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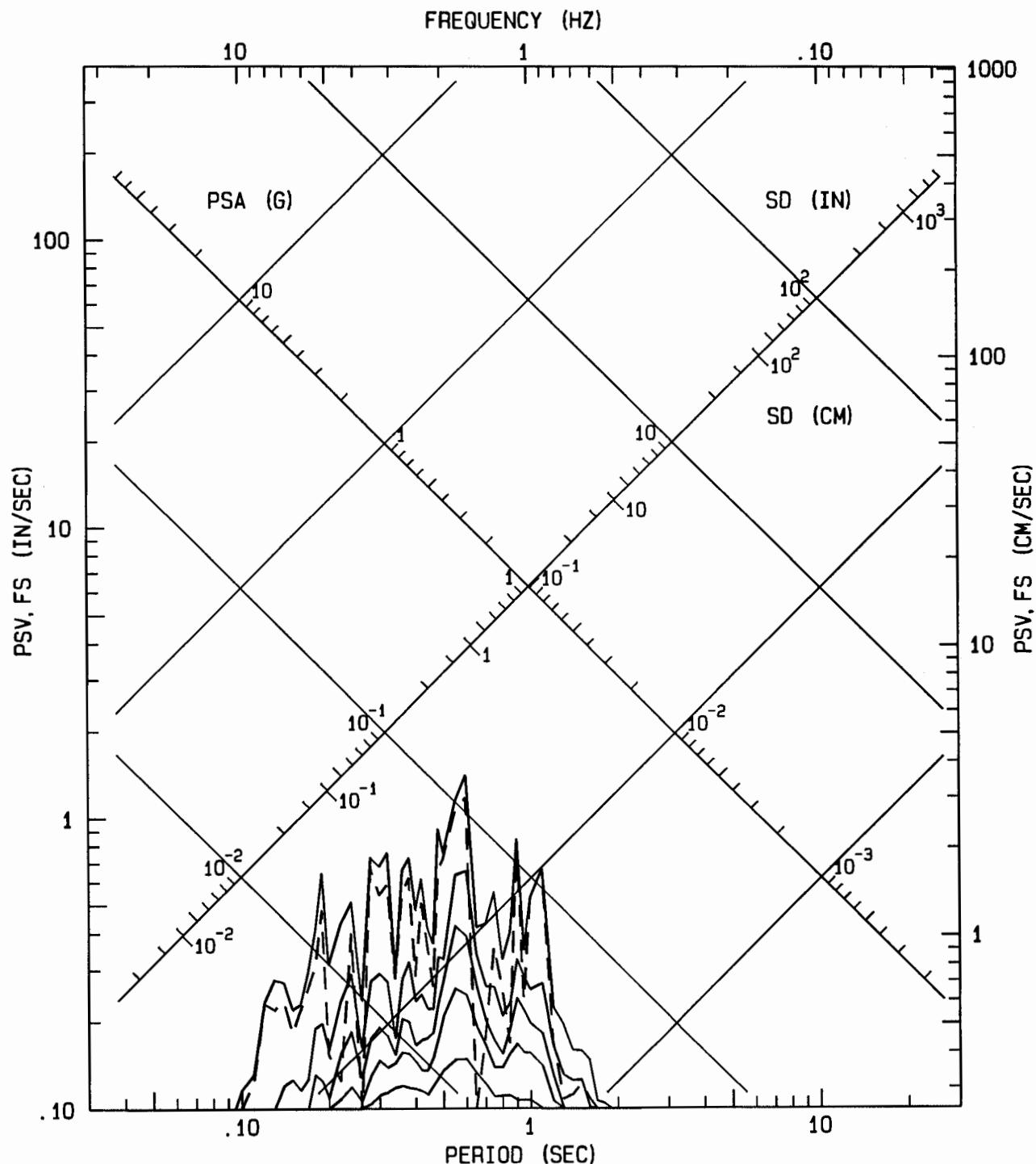
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TREASURE ISLAND - GEOTECHNICAL ARRAY
CHN 1: 360 DEG (SURFACE)
ACCELEROMGRAM BANDPASS-FILTERED WITH RAMPS AT .30-.60 TO 23.0-25.0 HZ.
58642-CS131-93027.04 122293.1004-QG93A131

— RESPONSE SPECTRA: PSV, PSA & SD — — FOURIER AMPLITUDE SPECTRUM: FS
DAMPING VALUES: 0, 2, 5, 10, 20%



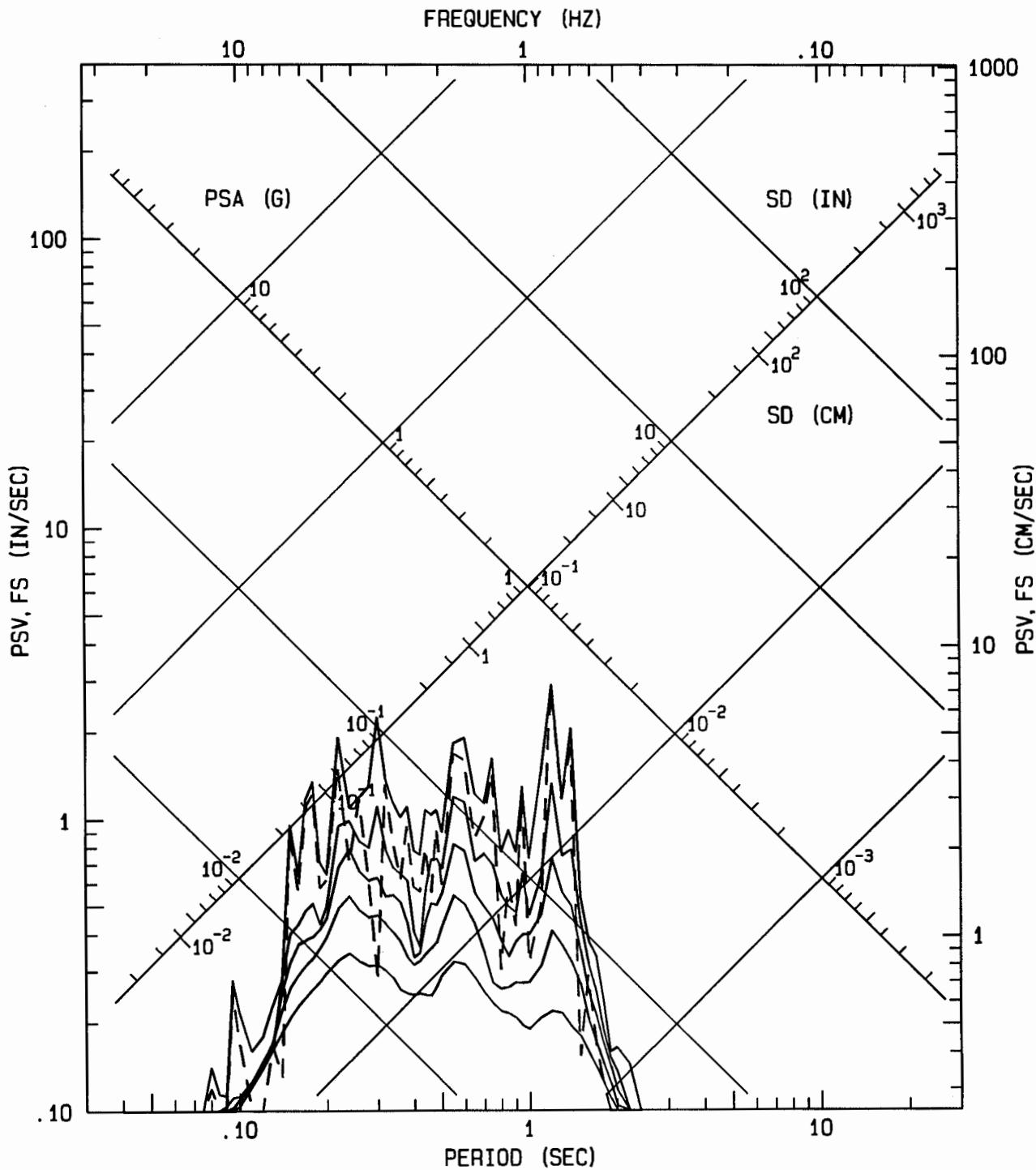
GILROY AREA EARTHQUAKE JANUARY 15, 1993 22:09 PST
TREASURE ISLAND - GEOTECHNICAL ARRAY
CHN 2: UP (SURFACE)
ACCELEROGRAM BANDPASS-FILTERED WITH RAMPS AT .30-.60 TO 23.0-25.0 Hz.
58642-CS131-93027.04 122293.1004-QG93A131

— RESPONSE SPECTRA: PSV, PSA & SD — — FOURIER AMPLITUDE SPECTRUM: FS
DAMPING VALUES: 0, 2, 5, 10, 20%



GILROY AREA EARTHQUAKE JANUARY 15, 1993 22:09 PST
TREASURE ISLAND - GEOTECHNICAL ARRAY
CHN 3: 90 DEG (SURFACE)
ACCELEROMGRAM BANDPASS-FILTERED WITH RAMPS AT .30-.60 TO 23.0-25.0 HZ.
58642-CS131-93027.04 122293.1004-QG93A131

— RESPONSE SPECTRA: PSV, PSA & SD — — FOURIER AMPLITUDE SPECTRUM: FS
DAMPING VALUES: 0, 2, 5, 10, 20%



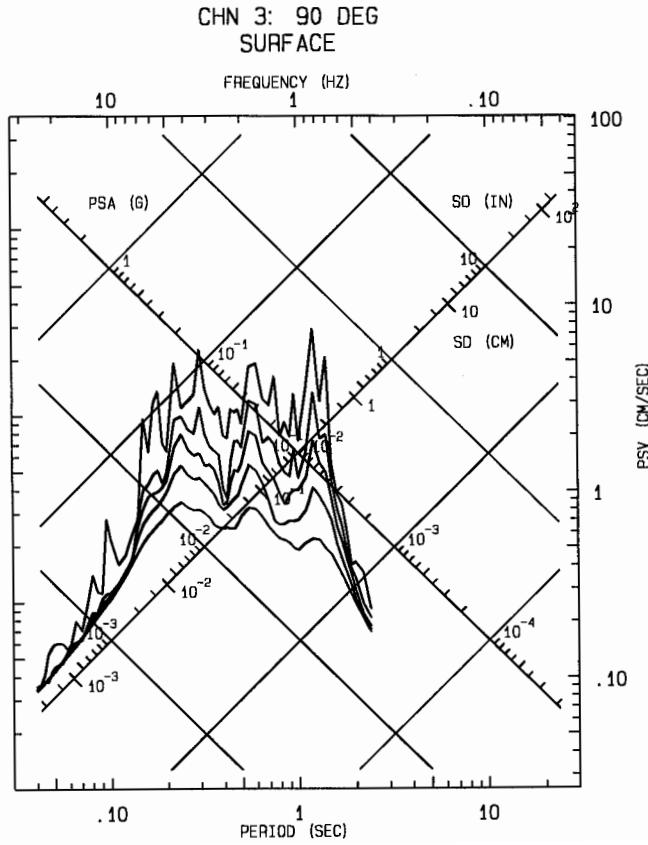
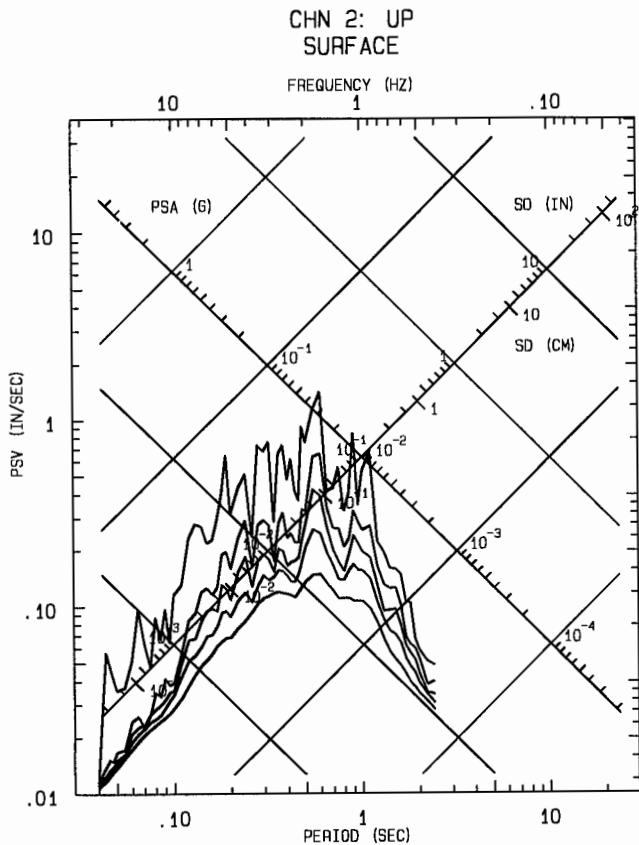
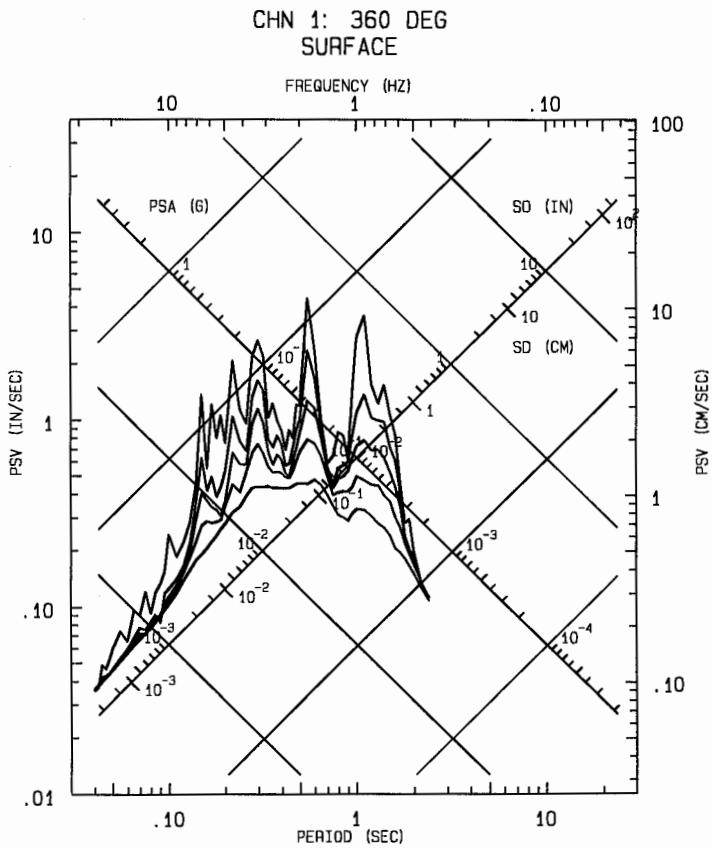
TREASURE ISLAND - GEOTECHNICAL ARRAY: CSMIP S/N 642

GILROY AREA EARTHQUAKE
JANUARY 15, 1993 22:09 PST

PHASE 3 DATA: RESPONSE SPECTRA
USABLE DATA BANDWIDTH: 0.51 TO 23.6 Hz
(0.04 TO 1.96 SEC)

RECORD ID: 58642-E0843-93027.04

— RESPONSE SPECTRA: PSV, PSA & SD
DAMPING VALUES: 0, 2, 5, 10, 20%



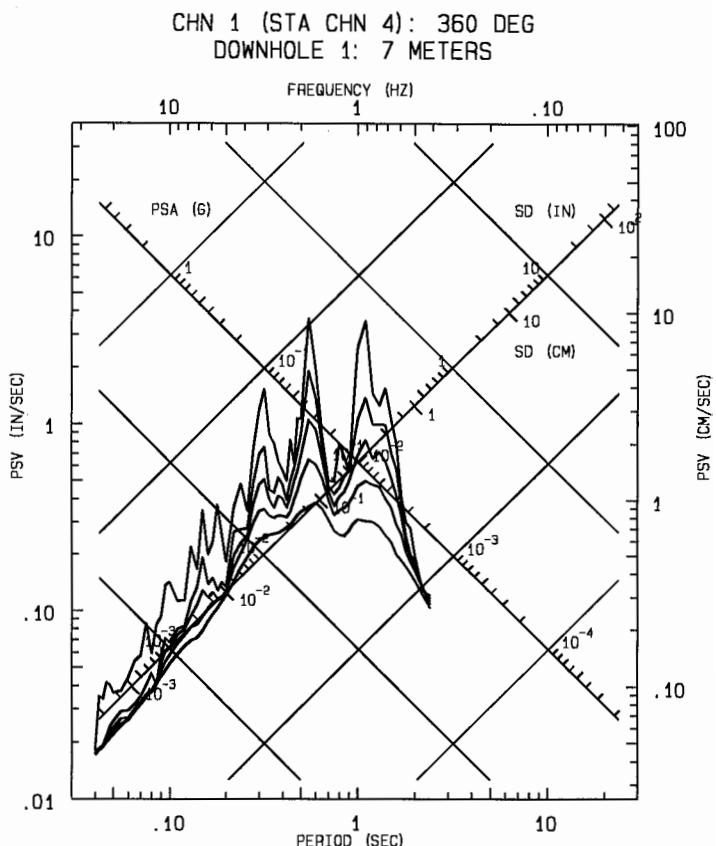
TREASURE ISLAND - GEOTECHNICAL ARRAY: CSMIP S/N 642

GILROY AREA EARTHQUAKE
JANUARY 15, 1993 22:09 PST

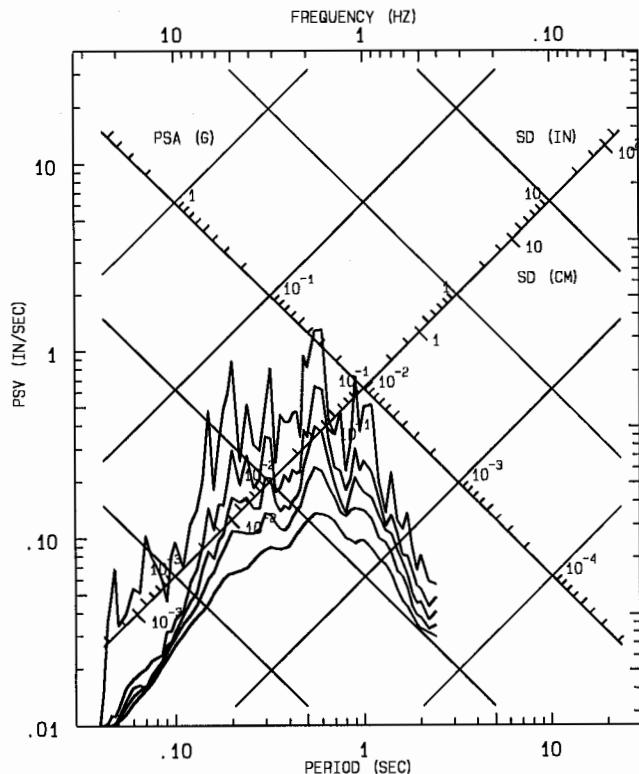
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USABLE DATA BANDWIDTH: 0.51 TO 23.6 Hz
(0.04 TO 1.96 SEC)

RECORD ID: 58642-E0886-93027.04

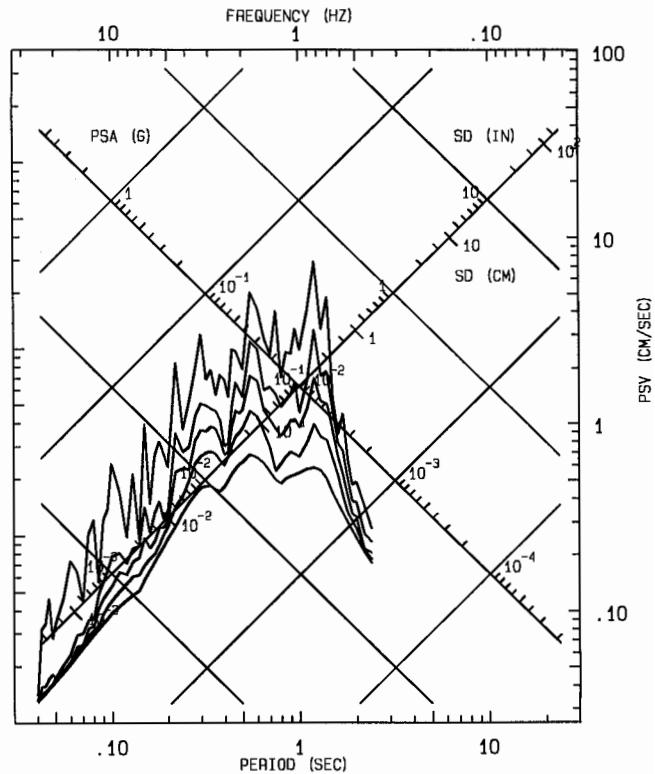
— RESPONSE SPECTRA: PSV, PSA & SD
DAMPING VALUES: 0, 2, 5, 10, 20%



CHN 2 (STA CHN 5): UP
DOWNHOLE 1: 7 METERS



CHN 3 (STA CHN 6): 90 DEG
DOWNHOLE 1: 7 METERS



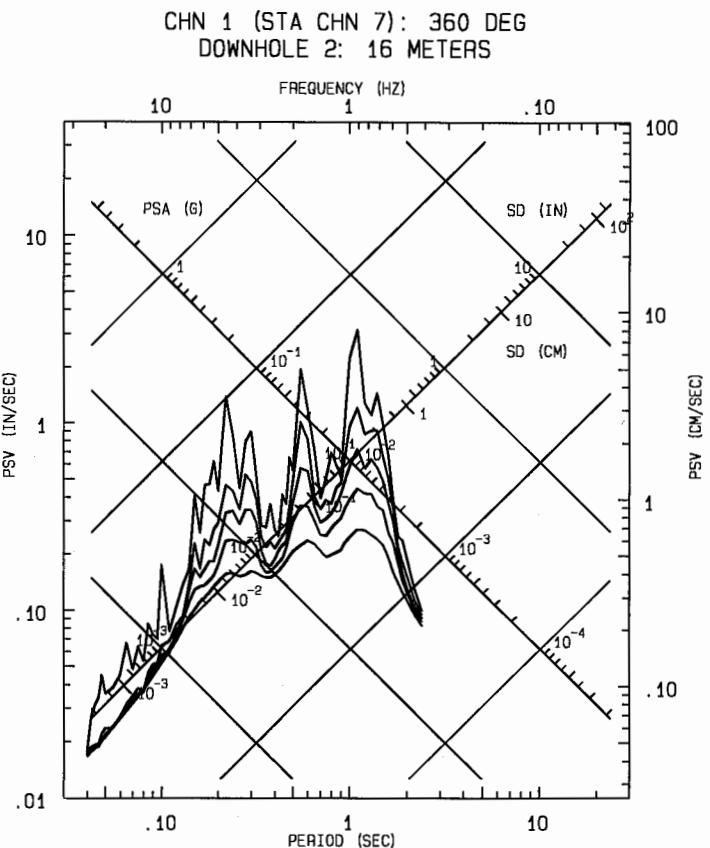
TREASURE ISLAND - GEOTECHNICAL ARRAY: CSMIP S/N 642

GILROY AREA EARTHQUAKE
JANUARY 15, 1993 22:09 PST

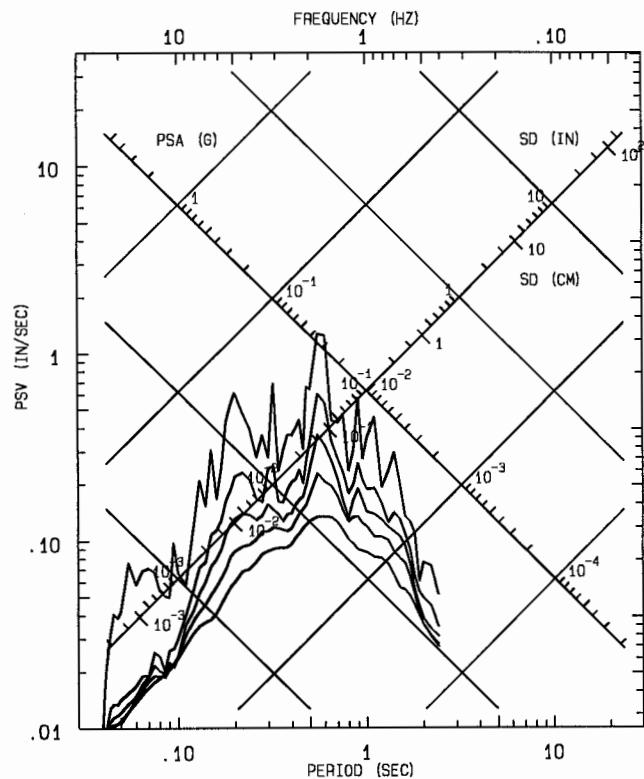
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USABLE DATA BANDWIDTH: 0.51 TO 23.6 Hz
(0.04 TO 1.96 SEC)

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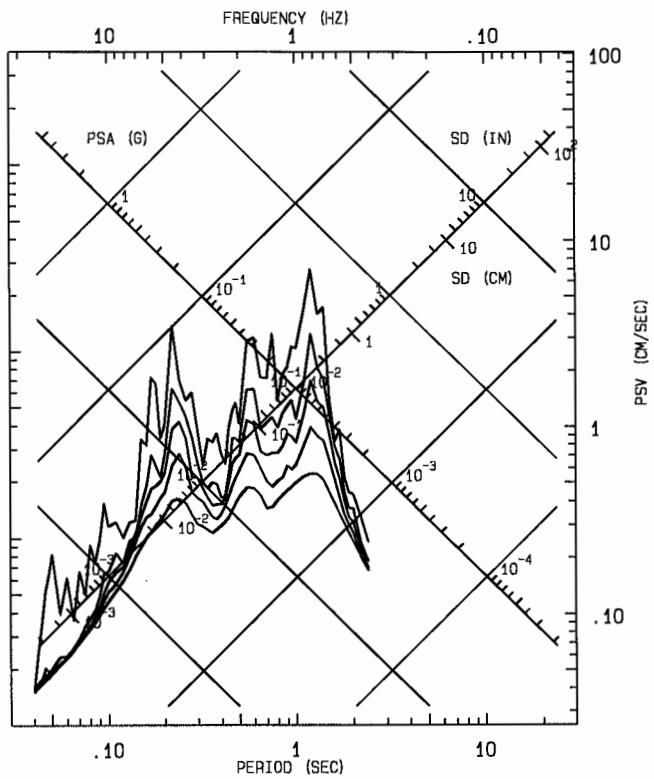
— RESPONSE SPECTRA: PSV, PSA & SD
DAMPING VALUES: 0, 2, 5, 10, 20%



CHN 2 (STA CHN 8): UP
DOWNHOLE 2: 16 METERS



CHN 3 (STA CHN 9): 90 DEG
DOWNHOLE 3: 16 METERS



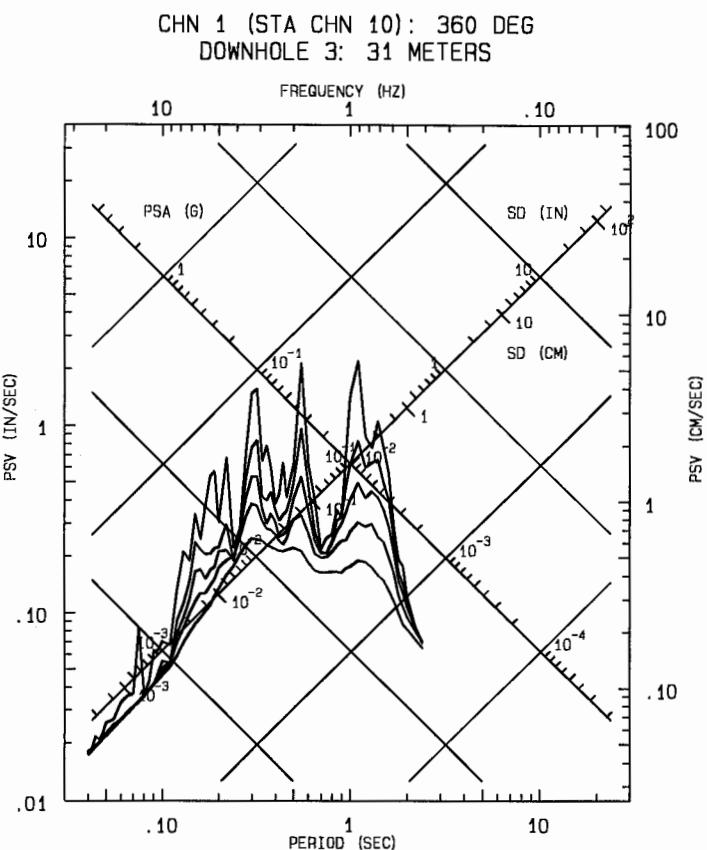
TREASURE ISLAND - GEOTECHNICAL ARRAY: CSMIP S/N 642

GILROY AREA EARTHQUAKE
JANUARY 15, 1993 22:09 PST

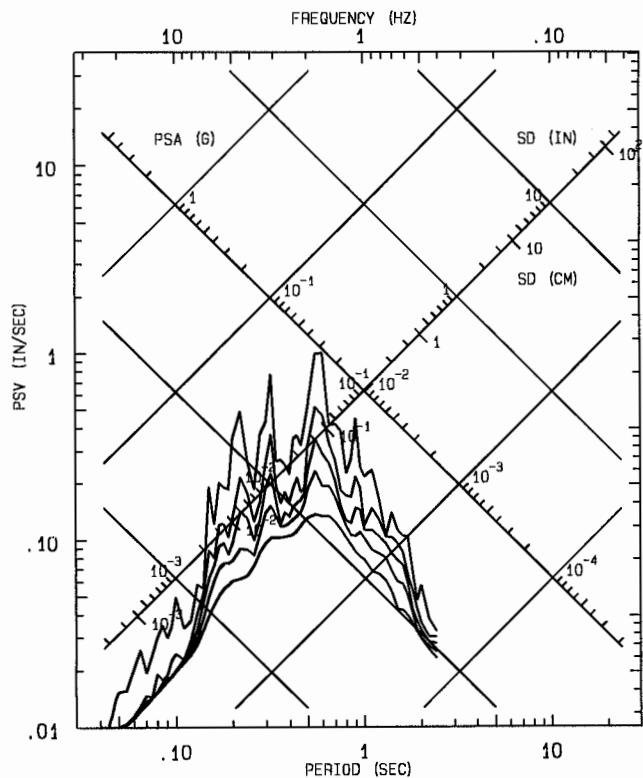
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USABLE DATA BANDWIDTH: 0.51 TO 23.6 Hz
(0.04 TO 1.96 SEC)

RECORD ID: 58642-G0229-93027.04

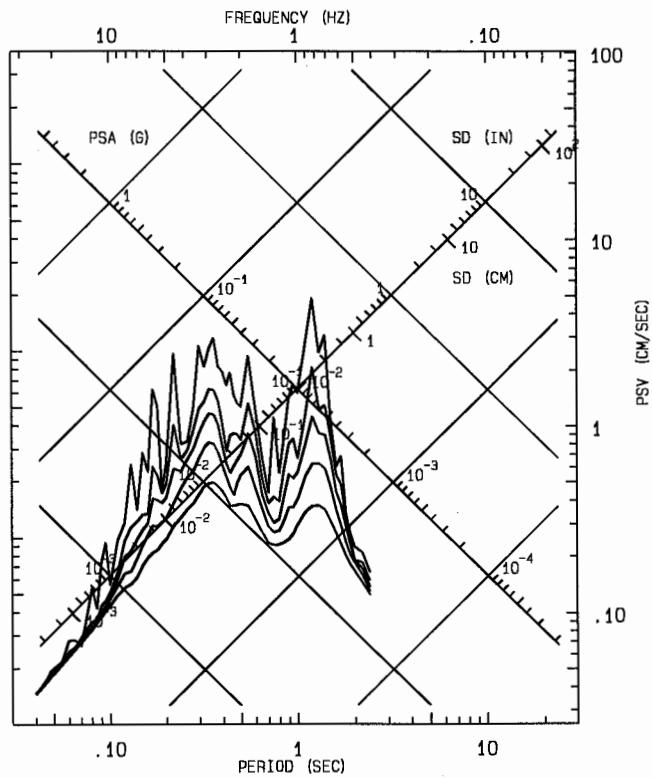
— RESPONSE SPECTRA: PSV, PSA & SD
DAMPING VALUES: 0, 2, 5, 10, 20%



CHN 2 (STA CHN 11): UP
DOWNHOLE 3: 31 METERS



CHN 3 (STA CHN 12): 90 DEG
DOWNHOLE 3: 31 METERS



TREASURE ISLAND - GEOTECHNICAL ARRAY: CSMIP S/N 642

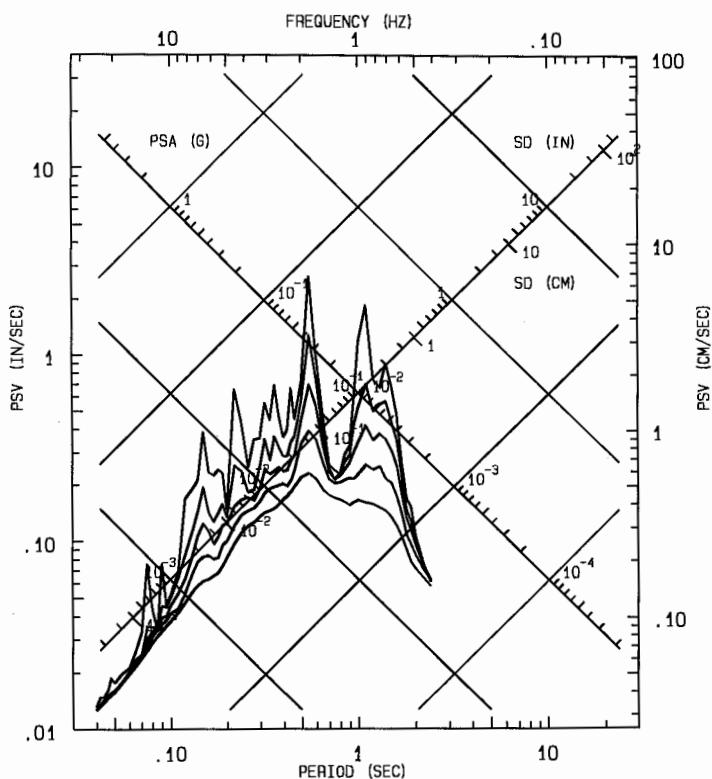
GILROY AREA EARTHQUAKE
JANUARY 15, 1993 22:09 PST

PHASE 3 DATA: RESPONSE SPECTRA
USABLE DATA BANDWIDTH: 0.51 TO 23.6 Hz
(0.04 TO 1.96 SEC)

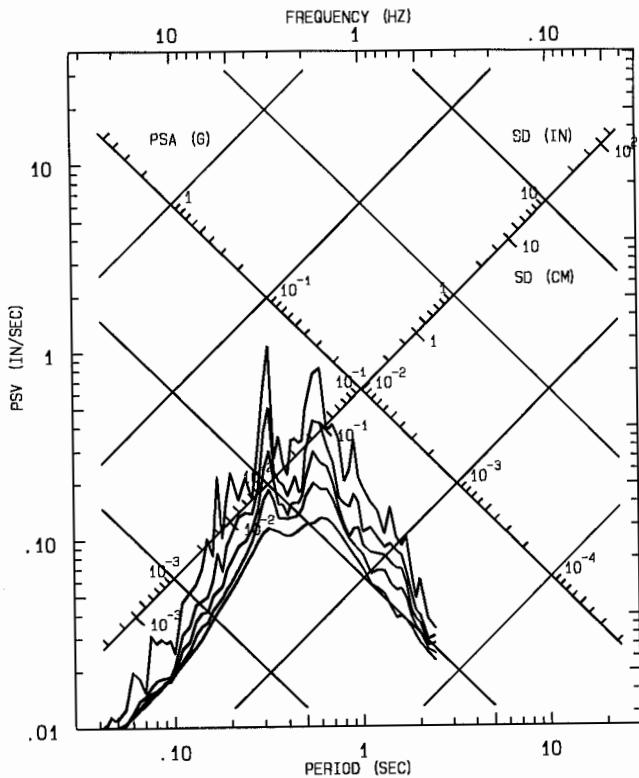
RECORD ID: 58642-G0229-93027.04

— RESPONSE SPECTRA: PSV, PSA & SD
DAMPING VALUES: 0, 2, 5, 10, 20%

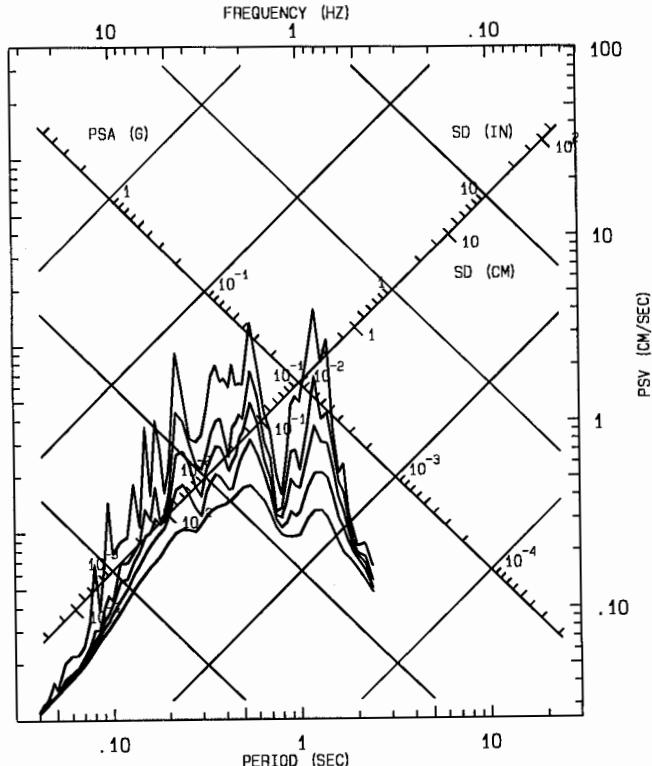
CHN 4 (STA CHN 13): 360 DEG
DOWNHOLE 4: 44 METERS



CHN 5 (STA CHN 14): UP
DOWNHOLE 4: 44 METERS



CHN 6 (STA CHN 15): 90 DEG
DOWNHOLE 4: 44 METERS



TREASURE ISLAND - GEOTECHNICAL ARRAY: CSMIP S/N 642

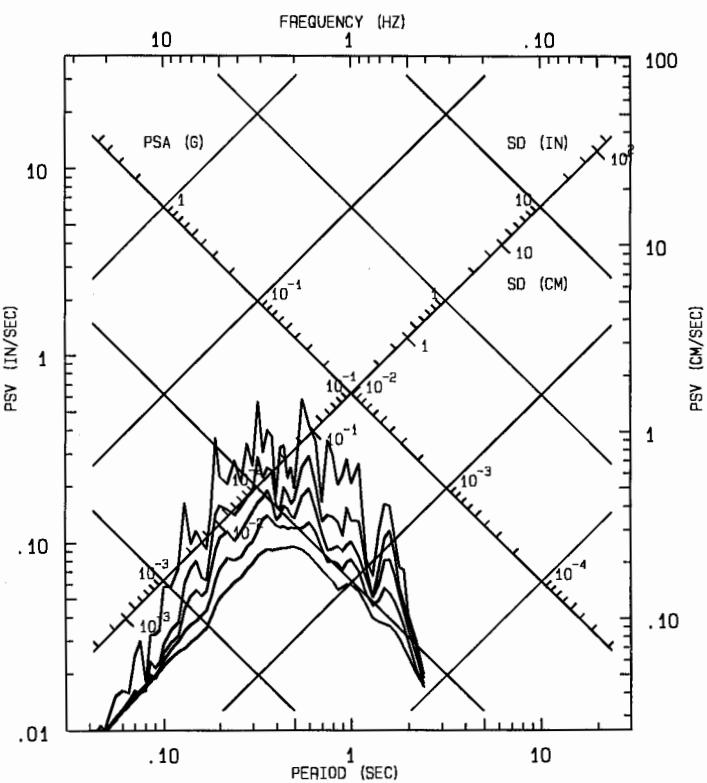
GILROY AREA EARTHQUAKE
JANUARY 15, 1993 22:09 PST

PHASE 3 DATA: RESPONSE SPECTRA
USABLE DATA BANDWIDTH: 0.51 TO 23.6 Hz
(0.04 TO 1.96 SEC)

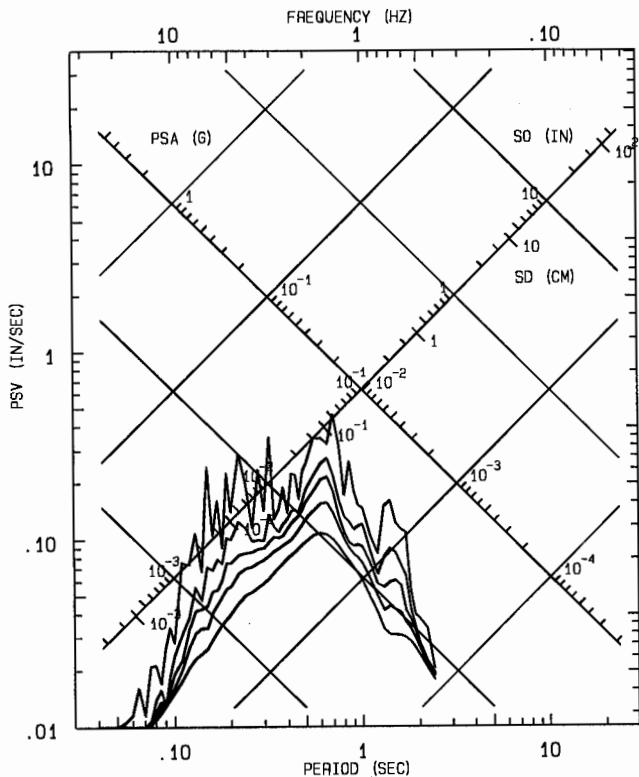
RECORD ID: 58642-G0181-93027.04

— RESPONSE SPECTRA: PSV, PSA & SD
DAMPING VALUES: 0, 2, 5, 10, 20%

CHN 1 (STA CHN 16): 360 DEG
DOWNHOLE 5: 104 METERS



CHN 2 (STA CHN 17): UP
DOWNHOLE 5: 104 METERS



CHN 3 (STA CHN 18): 90 DEG
DOWNHOLE 5: 104 METERS

